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15 March 1980

MILITARY STANDARD

STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

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DEPARTMENT OF DEFENSE
Washington, DC 20360

Standard General Requirements for Electronic Equipment

MIL-STD-454H

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Aeronautical Systems Division, Attn: ENESS, Wright-Patterson AFB, Ohio 45433, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This standard is the technical baseline for the design and construction of electronic equipment for the Department of Defense. It captures in one document, under suitable subject headings, fundamental design requirements for twelve general electronic specifications. The opportunity to focus on a single document, afforded to contractors, results in substantial savings to the Government. This standard was prepared and is biannually updated through the cooperative efforts of Government and industry. The following Government documents are intimately associated with this standard:

MIL-I-983	Interior Communication Equipment, Naval Shipboard, Basic Design Requirements for
MIL-E-4158	Electronic Equipment, Ground, General Requirements for
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
MIL-E-8189	Electronic Equipment, Missiles, Boosters and Allied Vehicles, General Specification for
MIL-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment
MIL-E-11991	Electrical-Electronic Equipment, Surface Guided Missile Weapon Systems, General Specification for
MIL-E-16400	Electronic Interior Communication and Navigation Equipment, Naval Ship and Shore, General Specification for
MIL-F-18870	Fire Control Equipment, Naval Ship and Shore, General Specification for
MIL-T-21200	Test Equipment for Use with Electronic and Electrical Equipment, General Specification for
MIL-T-28800	Test Equipment for Use with Electrical and Electronic Equipment, General Specification for
FAA-G-2100	Electronic Equipment, General Requirements

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STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

1. SCOPE

1.1 Requirements applicable to electronic equipment. This standard covers the common requirements to be used in military specifications for electronic equipment.

1.2 Revision of requirements. Revisions of individual requirements are indicated by a date below the requirement number located at the bottom of the page. A note, "Supersedes Requirement (no.) (date)", is placed in the lower corner of each revised page, opposite the requirement number and date. When the basic document is revised, those requirements not affected by change retain their existing date.

1.2.1 Although individual requirements are reviewed and updated or validated biannually (or oftener as required), requirements are not redated unless technical changes are made.

1.3 Method of reference. Requirements contained herein shall be referenced in the individual specification by specifying this standard and the requirement number.

1.4 Interrelationship of requirements. Each requirement is intended to cover some discipline in the design of equipment, such as a procedure, a process or the selection and application of parts and materials. Many of these disciplines, however, cannot retain a clear-cut separation or isolation from others so that when requirements of MIL-STD-454 are referenced in a specification some requirements will undoubtedly have a direct interrelationship with other requirements. This interrelationship should be taken into consideration when invoking or using these requirements.

2. APPLICABLE DOCUMENTS

* 2.1 See each individual requirement for reference to any applicable documents contained therein. Documents referenced in the individual requirements apply to the extent specified therein.

* 2.1.1 Unless otherwise specified, the applicable issues shall be those in effect on the date of the invitation for bids or request for proposal. The applicable issue of industry documents shall be the issue specified in paragraph 2 of the individual requirement.

2.1.2 Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

2.1.3 Addresses for obtaining documents referenced herein but not obtainable from the Government are as follows:

AGMA American Gear Manufacturers Association
1330 Massachusetts Ave., NW
Washington, DC 20005

ANSI American National Standards Institute
1430 Broadway
New York, NY 10018

ASM American Society for Metals
Metals Park, OH 44073

ASTM American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

AWS American Welding Society
2501 NW 7th Street
Miami, FL 33125

NAS National Standards Association
1321 Fourteenth Street, NW
Washington, DC 20005

NFPA National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

3. DEFINITIONS

3.1 Applicable to individual requirements only.

4. GENERAL REQUIREMENTS

4.1 Application. The requirements contained herein are intended to provide uniform requirements applicable to electronic equipment and shall be incorporated by reference in general equipment specifications. Other documents may reference requirements when applicable.

4.2 Use of selection and application standards. When a selection and application standard is invoked in a requirement, the devices or parts selected shall conform to the applicable military specifications referenced in the standard.

5. DETAIL REQUIREMENTS

5.1 Individual requirements for electronic equipment follow.

6. NOTES

6.1 The margins of this standard are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This is done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

Custodians:
Army - ER
Navy - AS
Air Force - 11

Review activities:
Army - AR, AV, CR, ME, MI
Navy - EC, SH, OS
Air Force - 17, 19, 85

Other:
DLA - ES, IS
FAA

Preparing activity:
Air Force - 10

Agent:
Air Force - 11

Project GDRQ-0009

REQUIREMENT 1

SAFETY (PERSONNEL HAZARD)

1. Purpose. This requirement establishes criteria for the design and development of military electronic equipment to promote maximum safety for personnel and equipment.

* 2. Documents applicable to Requirement 1:

MIL-B-5087	Bonding, Electrical, and Lightning Protection, For Aerospace Systems
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety Shielding
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-HDBK-600	Guidelines for Identification, Markings, Labeling, Storage, and Transportation of Radioactive Commodities
ANSI C95.2-1966 (R 1974)	Radio Frequency Radiation Hazard Warning Symbol
ANSI N2.1-1969	Radiation Symbol
ANSI Z35.1-1972	Accident Prevention Signs, Specification for
ANSI Z35.2-1968	Accident Prevention Tags, Specification for
ANSI Z53.1-1979	Marking Physical Hazards, Safety Color Code for
NFPA 70-1981	National Electric Code
Code of Federal Regulations, Title 10, Chapter I, Part 20	
Code of Federal Regulations, Title 21, Chapter I, Subchapter J	
Code of Federal Regulations, Title 29, Chapter XVII, Part 1910	

3. Definitions. The following definitions apply to Requirement 1.

3.1 Chassis, electrical equipment. The chassis is a structural item fabricated in such manner as to facilitate assemblage and interconnection of electrical or electronic items for the specific purpose of providing a basis for electrical or electronic circuits. It normally has drilled or stamped holes to accommodate the items but may include only the items necessary for its own mounting and support.

3.2 Frame. The frame is any construction system fitted and united together, designed for mounting or supporting electrical or electronic parts or units.

3.3 Fail-safe. The design feature of a part, unit or equipment which causes the item to fail only into a non-hazardous mode.

4. General consideration. The design and development of all military electronic equipment shall provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof. Equipment design for personnel safety shall be equal to or better than the appropriate requirements of the Occupational Safety and Health Act (OSHA) as identified in Title 29, Part 1910, of the Code of Federal Regulations.

4.1 Additional considerations. Proper instructions in accident prevention and first-aid procedures should be given all persons engaged in electrical work to fully inform them of the hazards involved.

a. Current rather than voltage is the most important variable in establishing the criterion for shock intensity. Three factors that determine the severity of electrical shock are: (1) quantity of current flowing through the body; (2) path of current through the body; and (3) duration of time that the current flows through the body. The voltage necessary to produce the fatal current is dependent upon the resistance of the body, contact conditions, and the path through the body. See table 1-I.

Table 1-I. Probable Effects of Shock

Current values (milliamperes)		Effects
AC 60 Hz	DC	
0-1	0-4	Perception
1-4	4-15	Surprise
4-21	15-80	Reflex action
21-40	80-160	Muscular inhibition
40-100	160-300	Respiratory block
Over 100	Over 300	Usually fatal

b. Sufficient current passing through any part of the body will cause severe burns and hemorrhages. However, relatively small currents can be lethal if the path includes a vital part of the body, such as the heart or lungs. Electrical burns are usually of two types, those produced by heat of the arc which occurs when the body touches a high-voltage circuit, and those caused by passage of electrical current through the skin and tissue. There are various methods of incorporating adequate safeguards for personnel, many of these methods being implicit in routine design procedures. However, additional design requirements and relative information pertaining to safety of personnel are outlined and detailed in this military standard. While current is the primary factor which determines shock severity, protection requirements of this standard are based upon the voltage involved to simplify their application. All voltages expressed in this standard apply to the dc value or the rms value for ac. In cases where the maximum current which can flow from a point is less than the values shown above for reflex action protection, requirements may be relaxed with the approval of the procuring activity.

c. Human engineering factors affecting safety should also be considered when establishing general or detailed design criteria. Rigorous detailed operational or maintenance procedures are not acceptable substitutes for an inherently safe design. Hazard and safety requirements of MIL-STD-1472 should be used as a guide.

5. Electrical. The design shall incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts rms or dc during normal operation of a complete equipment. Means shall be provided so that power may be cut off while installing, replacing, or interchanging a complete equipment,

assembly, or part thereof. Personnel shall be protected from capacitor discharges and when changing fuses or tubes. The main power ON-OFF switch located on the equipment (clearly labeled as such) shall cut off all power to the complete equipment. The power input side of the switch and the incoming power line connections shall be given physical protection against accidental contact. Suitable internal protective measures are defined in table 1-II.

* 5.1 Electrical power. Interface with electrical power sources shall be in accordance with the applicable regulations or requirements. (For example, commercial power input shall be in accordance with NFPA 70.)

* 5.2 Ground potential. The design and construction of the equipment shall insure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation. The design shall include consideration of ground currents and voltage limits (possible arcing) established on a basis of hazardous location. Any external or interconnecting cable, where a ground is part of the circuit, shall carry a ground wire in the cable terminated at both ends in the same manner as the other conductors. In no case, except with coaxial cables, shall the shield be depended upon for a current-carrying ground connection. Antenna and transmission line terminals shall be at ground potential, except for radio frequency (rf) energy on their external surfaces. Plugs and convenience outlets for use with metal cased portable tools and equipment shall have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptacle, and the grounding pin shall make first, break last.

5.3 Grounding. Ground connections to shields, hinges, and other mechanical parts shall not be made to complete electrical circuits. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for the static ground, power ground and, when applicable, airborne return leads. The path from the tie point to ground shall:

a. Be continuous and permanent.

b. Have ample carrying capacity to conduct safely any fault currents that may be imposed upon it.

c. Have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuits. Unused wires installed in lines (conduit or cables) shall be grounded to allow for stray or static electricity discharge.

d. Have sufficient mechanical strength of the material to minimize possibility of ground disconnection.

Table 1-II. Suitable Internal Protective Measures 1/

Type of protection	None 2/	Guards and barriers	Enclosures	Marking		Interlocks		Discharge devices	
				Caution	Danger	With bypass	No 3/ bypass	Auto-matic	Shorting rods
See paragraph		5.7	5.8 5.7.1	9.2a	9.2b	5.8b	5.8c	5.13	5.9
Voltage range									
0 - 30 Volts	X								
30+ - 70 Volts	X							X	
70+ - 500 Volts		X		X		X		X	X
500+ - 1000 Volts			X		X		X	X	X
1000 Volts up			X		X		X	X	X

1/ Confine the application of headings to voltage ranges checked. However, more than one option may be available on design requirements.

2/ Although no specific requirements exist for servicing 0 - 70 volts, designs should be reviewed for possible hazards in accordance with table 1-I.

3/ Designs may use "No bypass" interlock applications below 500 volts; but the intent here is to imply complete enclosure.

5.3.1 Hinged or slide mounted panels and doors. Panels and doors containing meters, switches, test points, etc, shall be attached or hinged in such a manner as to insure that they are at the same ground potential as the equipment in which they are mounted whether in a closed or open position. Hinges or slides are not considered adequate grounding paths, therefore doors and panels with hinges or slides shall be grounded by use of a flexible ground strap. A ground shall be considered satisfactory if the electrical connection between the door or panel and the system tie point exhibits a resistance of 0.1 ohm or less and has sufficient ampacity to insure the reliable and immediate tripping of equipment over-current protection devices. Hardware used for mounting of meters, switches, test points, etc, shall be grounded whenever possible.

5.4 Grounding to chassis. Ground connection to an electrically conductive chassis or frame shall be mechanically secured by soldering to a spotwelded terminal lug or to a portion of the chassis or frame that has been formed into a soldering lug, or by use of a terminal on the ground wire and then securing the terminal by a screw, nut, and lockwasher. The screw shall fit in a tapped hole in the chassis or frame or it shall be held in a through-hole by a nut. When the chassis or frame is made of steel, the metal around the screw hole shall be plated or tinned to provide a corrosion resistant connection. When aluminum or alumium alloys are used, the metal around the grounding screw or bolt hole may be covered with a corrosion resistant surface film only if the resistance through the film is not more than 0.002 ohm.

5.5 Shielding. Except where a conflict with single-point shield grounding requirements would be created, shielding on wire or cable shall be grounded to the chassis or frame in a manner specified in 5.4. The shielding shall be secured to prevent it from contacting exposed current-carrying parts or grounding to the chassis or frame at any point other than the ground termination. The shielding shall end at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding.

5.6 Bonding in hazardous areas. Electronic equipment to be installed in areas where explosive or fire hazards exist shall be bonded in accordance with MIL-B-5087 for aerospace systems, MIL-STD-1310 for shipboard sytems, and NFPA 70-1978, Chapter 5, for ground systems or as otherwise specified in the detail equipment specification.

5.7 Guards and barriers. All contacts, terminals and like devices having voltages between 70 and 500 volts rms or dc with respect to ground shall be guarded from accidental contact by personnel if such points are exposed to contact during direct support or operator maintenance. Test probe holes may be provided in the barriers or guards where maintenance testing is required.

5.7.1 High voltage guarding. Assemblies operating at potentials in excess of 500 volts shall be completely enclosed from the remainder of the assembly and interlocked in accordance with 5.8.

5.7.2 Permanent terminations. Terminations such as soldered connections to transformers, connectors, splices, etc, which are normally permanent and not used during routine maintenance testing, may be protected by permanent insulation such as shrink sleeving, tubing, insulating shields, etc, provided the material is rated for the potential exposed voltage.

5.7.3 Guarding of rf voltages. Transmitter output terminals, antennas and other devices that carry sufficient radio frequency (rf) voltage to burn or injure personnel shall be protected from accidental contact in the same manner as for ac voltages in the 70 to 500 volt range.

5.8 Interlocks. Various equipment designs require different approaches to the use of interlocks. Interlock use does not modify any other requirements of this standard and shall be consistent with equipment or system specifications. Equipment subassemblies operating in excess of 500 volts shall be considered guarded from accidental contact only if they are completely enclosed from the remainder of the equipment and are separately protected by nonbypassable interlocks. (An example of an equipment where such compartmentalization is desirable is a display unit which utilizes a high voltage power supply for a cathode ray tube.) Modularized or sealed high voltage assemblies which are opened only at depot level are exempt from interlocking requirements when approved by the procuring activity. When a unit is provided with access doors, covers or plates, these access points shall be interlocked as follows:

a. No interlocks are required when all potentials in excess of 70 volts are completely protected with guards or barriers to prevent accidental contact under all conditions of operation or any level of maintenance.

b. Bypassable interlocks are required when voltages between 70 and 500 volts are exposed when the access door, cover or plate is opened. Note that these internal voltages are allowed to be unguarded only if they are not exposed during direct support or operator maintenance.

c. Nonbypassable interlocks are required when any voltage in excess of 500 volts is exposed to accidental contact when the access door, cover or plate is opened.

5.9 Shorting rods. Shorting rods shall be provided with all transmitting equipment where voltages are in excess of 70 volts rms or dc. Wherever size permits, shorting rods shall be stored within the transmitting equipment, be permanently attached and readily accessible to maintenance personnel. The permanently attached rod shall be connected through a flexible stranded copper wire (covered with a transparent sleeving) to the stud provided at the transmitter main frame. A grounding stud shall be provided in all other transmitting equipment to permit attachment of a portable shorting rod. The connection to the stud shall be such that accidental loosening or high resistance to the ground shall be prevented.

5.10 Meter safety. Unless otherwise specified in the equipment specification, meters shall have provision for overload bypass or alternate protection to eliminate high voltage potential or current at the terminals in the event of meter failure.

5.11 High voltage protection. When the operation or maintenance of equipment employing potentials in excess of 300 volts peak could require that these voltages be measured, the equipment shall be provided with test points so that these voltages can be measured at relatively low potential level, but in no case shall the potential exceed 300 volts peak relative to ground. This may be accomplished through the application of voltage dividers or other techniques, such as the use of safety-type panel meters and multipliers. Test points with voltages above 30 volts shall have the conducting material recessed a distance no less than the diameter of the probe hole and a minimum of 0.06 inch. If a voltage divider is used, the voltage divider resistance between the test point and ground must consist of at least two equally valued resistors in parallel. Full details shall be given in the instruction book or maintenance manual as to the method used in the equipment to obtain the voltage at the test points.

* 5.12 High current protection. Power sources capable of supplying high current can be hazardous, regardless of the voltage at which they operate because of the arcing and heat generated if accidentally short circuited. All power busses supplying 25 amperes or over should be protected against accidental short circuiting by tools, jewelry or removable conductive assemblies. This may be accomplished by one or more of the following:

a. Use of guards and barriers.

b. Sufficient space separation to prevent short circuits.

c. Caution - warning signs.

* 5.13 Discharging devices. Discharging devices shall be provided to discharge high voltage circuits and capacitors unless they discharge to 30 volts within two seconds or less after power removal. These protective devices shall be positive acting, highly reliable, and shall actuate automatically when the case or rack is opened. Shorting bars should be actuated either by mechanical release or by an electrical solenoid when the door or cover is open. When resistive bleeder networks are used to discharge capacitors, the bleeder network shall consist of a least two equal valued resistors in parallel. The particular discharging device that is chosen must insure that the capacitor is discharged to 30 volts or less within two seconds.

5.14 Connections for external power. Application of power to externally powered test equipment or portable electronic equipment shall meet the following requirements:

a. Power shall be controlled by a power ON-OFF switch located on the front panel. A green indicator lamp shall be provided to indicate "power on" to the test set, except for low-power dry-battery-operated equipment.

b. Neither side of the supply voltage shall be directly connected to the chassis.

c. A conductor intended to be used as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. This shall be green or green with one or more yellow stripes.

5.15 Connectors, electrical. Connectors used to provide separation of or connection to multiple electric circuits shall be selected so that it will be impossible to insert the wrong plug in a receptacle or other mating unit. Where design considerations require plug and receptacles of similar configuration in close proximity, the mating plugs and receptacles shall be suitably coded or marked to clearly indicate the mating connections. Plugs and receptacles shall not be of similar configuration if the major unit contains explosive items. The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnect methods are used. Exposed pin contacts shall not be energized (hot) after being disconnected from the socket contacts.

6. Radiation

6.1 Microwave, radio frequency (rf), X, and laser radiation limits

6.1.1 Applicability of federal standards. The design of all equipment for which a federal standard exists under the Code of Federal Regulations (CFR), Title 21, Chapter I, Subchapter J, on the Radiation Control for Health and Safety Act of 1968, shall conform to the appropriate federal standard.

6.1.2 Microwave and rf radiation. All electronic equipment or electrical devices capable of emitting microwave or rf radiation between 10 MHz and 100 GHz shall be so designed, fabricated, shielded and operated as to avoid overexposure of personnel. In areas where unintended radiation levels exist, equipment design and installation in any unrestricted area accessible to personnel shall be limited to the following, measured 5 cm from the cabinet, shield, or source:

CW Power Densities and Field Strengths

Power density	10 mW/cm^2
Electric field strength	200 V/m(rms)
Magnetic field strength	0.5 A/m(rms)

Modulated Fields with Energy Density and Squares of Field Strengths Averaged over any 0.1 Hour Period:

Power density	10 mW/cm^2
Energy density	1 mWh/cm^2
Mean squared electric field strength	40,000 $V2/m^2$
Mean squared magnetic field strength	0.25 A^2/m^2

Shields, covers, doors, etc, which when opened or removed will allow microwave and rf radiation to exceed the above, shall be provided with nonbypassable interlocks.

6.1.3 X radiation. All electronic or electrical devices capable of producing X radiation shall be so designed, fabricated, shielded and operated as to keep personnel exposure as low as reasonably achievable. For equipment and installation design, shielding requirements shall be maintained at all times which limit radiation levels to not greater than 2 milliroentgens (mr) in any

one hour and 100 mr in any 7 consecutive days at the operator position or within 5 cm from the equipment (whichever is closer) in any unrestricted area accessible to personnel. In addition, these levels shall be reduced whenever necessary to ensure that exposed personnel never receive an absorbed dose to the whole body or any critical organ in excess of 125 millirem per calendar quarter or 500 millirems per year. Other exposure shall be based on application criteria and limits as required by Nuclear Regulatory Commission Rules and Regulations, CFR, Title 10, Chapter I, Part 20; OSHA Regulations, CFR, Title 29, Chapter XVII, Part 1910.96; and FDA Regulation, CFR, Title 21, Chapter I, Subchapter J, Radiological Health. Equipment which, when shields, covers, doors, etc, are removed, will allow X radiation to exceed 2.0 mr per hour shall be provided with nonbypassable interlocks.

6.1.4 Laser radiation. Laser equipment and system design, installation, and written operational and maintenance procedures shall conform to CFR, Title 21, Chapter I, Subchapter J, Part 1040. If Title 21 cannot be met because of operational requirements, an exemption shall be requested from the procuring activity and applicable military laser safety regulations shall be used as a design requirement.

6.1.5 Radiation level tests. All microwave, rf, X, and laser radiation levels emanating from equipment shall be verified by documented tests to demonstrate compliance with this requirement. When modifications to the equipment affect performance or intended function, radiation levels shall be verified.

7. Switches

7.1 Interlocks. Unless otherwise specified, interlock switches shall conform to one or more of the following:

a. The interlock is an automatic switch which eliminates all power from the equipment when an access door, cover or plate is removed.

b. The bypassable interlock is an automatic switch with a manually operated electrical bypass device to allow equipment maintenance operations. This bypass device shall be of such design that closing the associated door, cover or plate will automatically open the bypass device and leave the interlock in position to function normally. Visual means shall be provided to indicate when the interlock is bypassed.

c. The nonbypassable interlock is a switch which has no provision for bypass.

7.2 Battle short

a. When required by the individual equipment specification, a battle short switch shall be provided on the main operating console or assembly to short-circuit all safety interlocks. An indicator light readily visible to personnel shall indicate that the battle short switch is ON.

b. If specified in the individual equipment specification, terminals shall be provided in each separate cabinet or console for connecting of external battle short switch or switches.

7.3 Safety switches. Safety switches which will deactivate associated mechanical drive units shall be provided for the purpose of disconnecting these units without disconnecting other parts of the equipment. All remotely located units and assemblies shall have provision for nonoverrideable safety switches to allow independent disconnect in the associated equipment.

7.4 Momentary override. When circuit considerations require noninterruption of power for efficient servicing, front panel momentary contact switches may be used to override interlocks and permit access to the manual override.

8. Mechanical Hazards. The design of the equipment shall be such as to provide maximum access and safety to personnel while installing, operating, and maintaining the equipment. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is complete and operating. Sharp projections on cabinets, doors, and similar parts shall be avoided. Doors or hinged covers shall be rounded at the corners and provided with stops to hold them open. Equipment design shall include provisions to prevent accidental pulling out of drawers or rack mounted equipment components which could cause equipment damage and injury to personnel. Equipment power switches shall be so designed and located that accidental contact by personnel will not place equipment in operation.

8.1 Mechanical interconnection. The design shall provide positive means to prevent the inadvertent reversing or mismating of fittings; couplings; fuel, oil, hydraulic, and pneumatic lines; mechanical linkage; and instrument leads and electrical connections. When prevention of mismating by design considerations is not feasible, coding or marking shall be employed when approved by the procuring activity. Coding and marking will not be approved as a substitute for proper design of items involving explosives, emergency, or safety critical systems.

8.2 Cathode ray tubes. Provision shall be incorporated to protect personnel from injury due to implosion of cathode ray tubes.

8.3 Glass fibers. Glass fiber materials shall not be used as the outer covering on cables, wire or other items where they may cause skin irritation to operating or maintenance personnel or where there is any evidence of glass protruding from the surface.

8.4 Insulation of controls. All control shafts and bushings thereof shall be grounded whenever practicable. Alternatively, the control knobs or levers and all attachment screws that can be contacted during use shall be electrically insulated from the shaft.

8.5 Temperature. Where people are involved, and under any condition of operation, exposed parts, including the enclosure of the equipment, shall not achieve a temperature in excess of 60°C at an ambient temperature of 25°C. The temperature of front panels and operating controls shall not exceed 49°C at the same ambient temperature.

9. Marking, signs, tags, and symbols

* 9.1 Marking

a. Guards, barriers, and access doors, covers or plates shall be marked to indicate the hazard which may be reached upon removal of such devices. When possible, marking shall be located such that it is not removed when the barrier or access door is removed. Additionally, hazards internal to a unit shall be marked adjacent to hazards if they are significantly different from those of surrounding items. Such a case would be a high voltage terminal in a group of low voltage devices.

b. Physical hazards shall be marked with color codes in accordance with ANSI Z53.1 where applicable to electronic equipment.

* 9.2 Signs. Danger, caution, etc, signs shall be used in accordance with ANSI Z35.1 to warn of specific hazards such as voltage, current, thermal, physical, etc. The markings shall be as permanent as the normal life expectancy of the equipment on which they are affixed.

a. For potentials between 70 and 500 volts, warning signs or shield labels shall read, as a minimum, "Caution - (Insert maximum voltage applicable) Volts". The letters shall be yellow gothic capitals on a black background. The voltage shall be black on a yellow background.

b. For potentials in excess of 500 volts, warning signs or shield labels shall read, as a minimum, "Danger - High Voltage - (Insert maximum voltage applicable) Volts". The letters shall be gothic capitals, color white or aluminum with a red background. The voltage shall be black on a white or aluminum background.

c. Microwave or radio frequency radiation signs shall be in accordance with ANSI C95.2. Labels shall be provided on all radiation shields to warn personnel of the radiation hazards involved upon removal thereof. Any item which can emit radiation levels in excess of those specified in paragraph 6 shall be labeled. Warning signs shall be posted in all areas having electronic equipment designed to operate between 10 MHz and 100 GHz with intended electromagnetic radiation levels exceeding those in paragraph 6.

d. (1) Laser labels shall be in accordance with CFR, Title 21, Chapter I, Subchapter J, Part 1040.

(2) Military exempt laser labels: A permanent label shall be affixed on all military laser systems that have been certified exempt from CFR, Title 21, Part 1040 (Performance Standards for Light-Emitting Products), which reads:

CAUTION

This electronic product has been exempted from FDA radiation safety performance standards, prescribed in the Code of Federal Regulations, Title 21, Chapter I, Subchapter J, pursuant to Exemption no. 76 EL-01 DOD issued on 26 July 1976. This product should not be used without adequate protective devices or procedures.

e. Shields which protect personnel from X radiation shall be labeled.

* 9.3 Tags. Coding for accident prevention tags shall be in accordance with ANSI Z35.2.

* 9.4 Marking of radioactive materials. The marking or labeling of commodities containing radioactive materials shall be in accordance with Nuclear Regulatory Commission Rules and Regulations CFR, Title 10, Chapter I, Part 20 and OSHA Regulation CFR, Title 29, Part 1910.96. MIL-HDBK-600 references known electronic items which require marking and may be used as a guide.

* 9.5 Symbols. The following symbols shall be used as applicable:

a. Ionizing radiation hazard - ANSI N2.1.

b. Microwave and radio frequency radiation - ANSI C95.2.

c. Laser symbol - CFR, Title 21, Chapter I, Subchapter J, Part 1040.

10. Hazardous and restrictive substances. Consideration of the hazard potential of a substance shall be given prior to material selection.

10.1 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the CFR, Title 29, Chapter XVII, Part 1910.

10.2 Gases or fumes. The materials, as installed in the equipment and under service conditions specified in the specific equipment specification, shall not liberate gases which combine with the atmosphere to form an acid or corrosive alkali, nor shall they liberate toxic or corrosive fumes which would be detrimental to the performance of the equipment or health of the equipment operators. The materials also shall not liberate gases which will produce an explosive atmosphere.

10.3 Mercury. Materials and parts containing mercury shall not be used unless use of mercury is specifically required or approved by the procuring activity.

10.4 Radioactive materials. Use of radioactive materials shall conform to Nuclear Regulatory Commission regulations and shall require approval of the procuring activity. Radium shall not be used to achieve self-luminosity.

REQUIREMENT 2

CAPACITORS

1. Purpose. This requirement establishes criteria for the selection and application of capacitors.

* 2. Documents applicable to Requirement 2:

MIL-C-19978	Capacitors, Fixed, Plastic (or Paper-Plastic) Dielectric, (Hermetically Sealed in Metal, Ceramic, or Glass Cases), Established and Non-established Reliability, General Specifications for
MIL-C-39003	Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum, Established Reliability, General Specification for
MIL-C-39006	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, Established Reliability, General Specification for
MIL-C-39006/22	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, (Polarized, Sintered Slug), 85°C (Voltage Derated to 125°C), Established Reliability, Style CLR79
MIL-C-39018	Capacitor, Fixed, Electrolytic (Aluminum Oxide), General Specification for
MIL-STD-198	Capacitors, Selection and Use of

* 3. Selection. Capacitors shall be selected and applied in accordance with MIL-STD-198.

3.1 Variable, compression type. Compression (spring plate) type variable capacitors shall not be used.

3.2 Fixed, paper dielectric. Paper, paper-plastic, and metallized paper capacitors in molded cases shall not be used.

* 3.3 Fixed, tantalum electrolytic. The use of wet slug tantalum capacitors (except tantalum cased units in accordance with MIL-C-39006/22) requires the approval of the procuring activity. For Naval Air Systems Command use, all wet slug tantalum capacitors require approval.

* 3.4 Fixed, aluminum electrolytic. Fixed, dry electrolytic (aluminum oxide) capacitors shall conform to MIL-C-39018 and shall be selected from MIL-STD-198. They shall be used only where capacitance values and other associated characteristics are not available in MIL-C-19978, MIL-C-39003, or MIL-C-39006. Use of aluminum oxide electrolytic capacitors shall require approval of the procuring activity.

REQUIREMENT 3

FLAMMABLE MATERIALS

1. Purpose. This requirement establishes tests for the determination of flammability of materials and the limitations on their use.

2. Documents applicable to Requirement 3:

ASTM D568-77	Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position, Test Method for
ASTM D635-77	Rate of burning and/or Extent and Time of Burning of Self-supporting Plastics in a Horizontal Position, Test Method for
ASTM D1000-76	Pressure-Sensitive Adhesive Coated Tapes Used for Electrical Insulation, Methods of Testing

3. Characteristics. In the design and construction of electrical or electronic circuits, materials used for electrical insulation or mechanical purposes which will support combustion or which are capable of causing an explosion when the equipment is subjected to the environmental conditions specified in the detail equipment specification, shall not be used unless specifically approved by the procuring activity.

3.1 The test used to determine the fire retardant feature shall be the test specified in the material specification. If the specification does not have such a test, materials shall be tested in accordance with ASTM D568-77 or ASTM D635-77, as applicable. Pressure sensitive adhesive tapes shall be tested in accordance with the flammability test in ASTM D1000-76.

3.2 Materials. Materials not covered by the test of 3.1 shall be tested in accordance with a procedure proposed by the manufacturer and approved by the procuring activity.

3.3 Additives. Additives shall not adversely affect the specified performance requirements of the basic materials. Fire retardance shall not be achieved by use of nonpermanent additives to the basic material.

REQUIREMENT 4

FUNGUS-INERT MATERIALS

1. Purpose. This requirement identifies those materials which are acceptable nonnutrients of fungus and establishes the conditions or treatments under which fungus nutrients are acceptable.

2. Documents applicable to Requirement 4:

ASTM G21-70 Determining Resistance of Synthetic Polymeric Materials to Fungi
Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Materials

a. For new designs, only inherently fungus-inert materials shall be used except that other materials may be used in hermetically sealed assemblies or other specifically approved items.

b. For reprocured equipment, if it is necessary to use nutrient materials in other than the above approved applications, they shall be treated by a method that will render the exposed surface fungus-resistant so that they will pass the test of 3.2. When materials are compounded with a permanently effective fungicide in order to pass the fungus test, there shall be no loss of the original electronic or physical properties required by the basic materials specification.

3.1 Fungus susceptibility. Group I in table 4-I lists those materials which are considered not to be nutrient to fungi in all modified states and grades. Group II lists materials which are not fungus-inert in all grades and therefore the fungus resistance of the materials selected shall be confirmed by testing in accordance with 3.2.

3.2 Fungus testing. Group II and treated materials selected for other than approved applications (see para 3) shall pass the fungus test specified in ASTM G21. There shall be no visible growth of fungus after 28 days. Certification by a qualified laboratory or by the material producer, based upon test data on record that the selected material passed the above test, will be sufficient evidence of acceptability.

3.2.1 Nonplastic materials. All nonplastic materials to be tested for fungus-susceptibility in accordance with 3.2, such as paint, ink, coatings, adhesives, lubricants, rubber, viscous damping fluids, silicone grease, etc, shall be prepared in the form of 2-inch squares or circles no more than 1/16-inch thick for testing. Liquid or paste materials shall be prepared by impregnating to saturation a sterile sample of glass fabric.

3.3 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

Table 4-I. Fungi Susceptibility of Materials

GROUP I (Fungus-inert in all modified states and grades)	
Acrylics	1/ Polyamide
Acrylonitrile-styrene	Polycarbonate
Acrylonitrile-vinyl-chloride copolymer	Polyester-glass fiber laminates
Asbestos	Polyethylene, high density (above 0.940)
Ceramics	Polyethylene terephthalate
Chlorinated polyether	Polyimide
Fluorinated ethylenepropylene copolymer (FEP)	Polymonochlorotrifluoroethylene
Glass	Polypropylene
Metals	Polystyrene
Mica	Polysulfone
Plastic laminates:	Polytetrafluoroethylene
Silicone-glass fiber	Polyvinylidene chloride
Phenolic-nylon fiber	Silicone resin
Diallyl phthalate	Siloxane-polyolefin polymer
Polyacrylonitrile	Siloxane-polystyrene
GROUP II (Not fungus-resistant in all grades; fungus-resistance shall be established by test)	
ABS (acrylonitrile-butadiene-styrene)	Polyethylene, low and medium density (0.940 and below)
Acetal resins	Polymethyl methacrylate
Cellulose acetate	Polyurethane (the ester types are particularly susceptible)
Cellulose acetate butyrate	Polyricinoleates
Epoxy-glass fiber laminates	Polyvinyl chloride
Epoxy-resin	Polyvinyl chloride-acetate
Lubricants	Polyvinyl fluoride
Melamine-formaldehyde	Rubbers, natural and synthetic
Organic polysulphides	Urea-formaldehyde
Phenol-formaldehyde	
Polydichlorostyrene	

1/ Literature shows that under certain conditions polyamides may be attacked by selective micro-organisms. However, for military applications they are considered group I.

REQUIREMENT 5

SOLDERING

1. Purpose. This requirement establishes procedures for making soldered electrical and electronic connections.

2. Documents applicable to Requirement 5:

O-E-760	Ethyl Alcohol (Ethanol), Denatured Alcohol, and Proprietary Solvents
O-T-236	Tetrachloroethylene (Perchloroethylene) Technical Grade
QQ-S-571	Solder; Tin Alloy; Tin-Lead Alloy; and Lead Alloys
TT-I-735	Isopropyl Alcohol
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-P-28809	Printed Wiring Assemblies
MIL-P-50884	Printed Wiring, Flexible, General Specification for
MIL-T-81533	Trichloroethane 1, 1, 1(Methyl Chloroform) Inhibited, Vapor Degreasing
MIL-P-81728	Plating, Tin-Lead (Electrodeposited)
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD 750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics

3. Materials

3.1 Flux. Rosin fluxes conforming to types R or RMA of MIL-F-14256 shall be used for making electrical and electronic connections except that type RA flux of MIL-F-14256 may be used on assemblies which will subsequently be tested for and conform to the cleanliness requirements of MIL-P-28809. However, solid wires with sleeve type insulation or stranded or braided wires shall not be soldered utilizing type RA flux. For the Army Electronics Research and Development Command (ERADCOM), Communications Research and Development Command (CORADCOM), and Avionics Research and Development Command (AVRADCOM), the use of RA flux requires approval. For fluxing purposes, a soldered joint which functions as both a mechanical and an electrical connection (for example, in grounding applications through a chassis) shall be considered an electrical connection.

3.2 Solder. Unless otherwise specified by the procuring activity, the solder alloy shall conform to composition Sn60, Sn62, or Sn63 of QQ-S-571. The flux of flux-cored solder shall be type R or RMA of QQ-S-571, except that the core may be type RA flux in solder used only on assemblies and connections which will subsequently be tested for and conform to the cleanliness requirements of MIL-P-28809. However, solid wires with sleeve type insulation or stranded or braided wires shall not be soldered utilizing type RA flux. For the Army Commands listed in 3.1, the use of RA flux requires approval.

4. Preparation of conductors and terminals

4.1 Stripping insulation. Sufficient insulation shall be stripped from the wire or leads to provide for insulation clearances as specified in 5.1.4. In stripping insulation, care should be taken to avoid nicking or otherwise

damaging the wire or the remaining insulation. The number of damaged or severed strands in a single lead shall not exceed the limits given in table 5-I. Leads used at a potential of 6kV or greater shall have no broken strands. Insulation discoloration resulting from thermal stripping is permissible.

Table 5-I. Limits

Number of strands	Maximum allowable nicked or broken strands
Less than 7	0
7-15	1
16-18	2
19-25	3
26-36	4
37-40	5
41 or more	6

4.2 Cleaning of conductors and terminals. Conductor surfaces to be soldered shall be clean prior to soldering. Cleaning may be as follows:

a. Grease and oil shall be removed from conductors and terminals by applying a noncorrosive solvent such as: 1, 1, 1-trichloroethane conforming to MIL-T-81533; ethyl alcohol conforming to O-E-760, type III or isopropyl alcohol conforming to TT-I-735; or tetrachloroethylene conforming to O-T-236.

b. Oxides and varnishes shall be removed by methods which do not damage leads or parts, and which do not cause contamination or hinder solder wetting.

c. Sand blasting shall not be used.

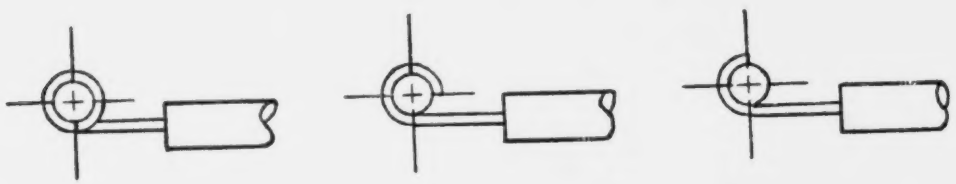
d. Dust or other loose matter shall be removed.

4.3 Pretinning (presolder coating) conductors and terminals. Wire and part leads, with or without attached terminals, shall meet the solderability requirements of Method 2026.3 of MIL-STD-750 for semiconductors, Method 2003.2 of MIL-STD-883 for microelectronics, and Method 208 of MIL-STD-202 for other electrical and electronic component parts. Pretinning (presolder coating) of electroplated tin-lead in accordance with MIL-P-81728, or hot dip solder which is 0.0003 inch minimum thickness may be used on parts which will subsequently be soldered. Tinning of a stranded wire shall not obscure the wire contour at the termination end of the insulation to permit inspection of the wire for damage. Heat sinks shall be applied to leads of heat sensitive parts during the tinning operation. The preconditioning/pretinning solder pot shall be maintained in accordance with 7.4.2. Wicking, the capillary flow of solder along the wire, is permitted; however, solder shall not obscure the contour of the conductor at the termination of the insulation. The leads of all devices to be planar mounted shall be pretinned prior to installation.

5. Attachment of wires and leads

5.1 Attachment of wires and leads to terminals

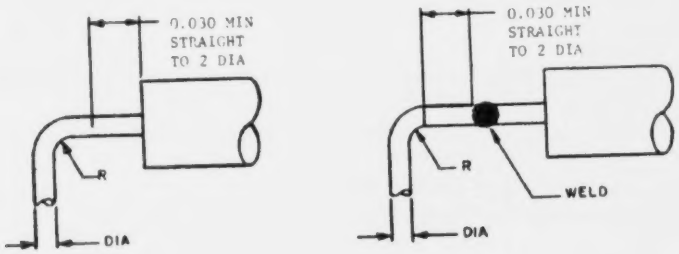
5.1.1 Wire and lead wrap-around. Leads and wires shall be mechanically secured to their terminals before soldering. Such mechanical securing shall prevent motion between the parts of a joint during the soldering operation. Leads and wires shall be wrapped around terminals for a minimum of one-half and not more than one full turn in a single layer only (see figure 5-1). For AWG 30 or smaller wire, a maximum of 3 turns may be used. Exception is made in the case of those small parts used for terminating conductors and to which such mechanical securing would be impracticable, such as connector solder cups, slotted terminal posts, heat shrinkable solder devices, etc. Lead extension shall be restricted to the limits required by design to prevent equipment malfunction. In no case shall wires be wrapped on each other.



a. Full Turn b. 3/4 Turn c. 1/2 Turn

Figure 5-1. Wire and Lead Wrap Around

5.1.2 Lead bends. The distance between the body of the part or weld and the bent section of a lead shall be at least twice the diameter of the lead but not less than 0.030 inch. Radii of bends shall conform to figure 5-2.

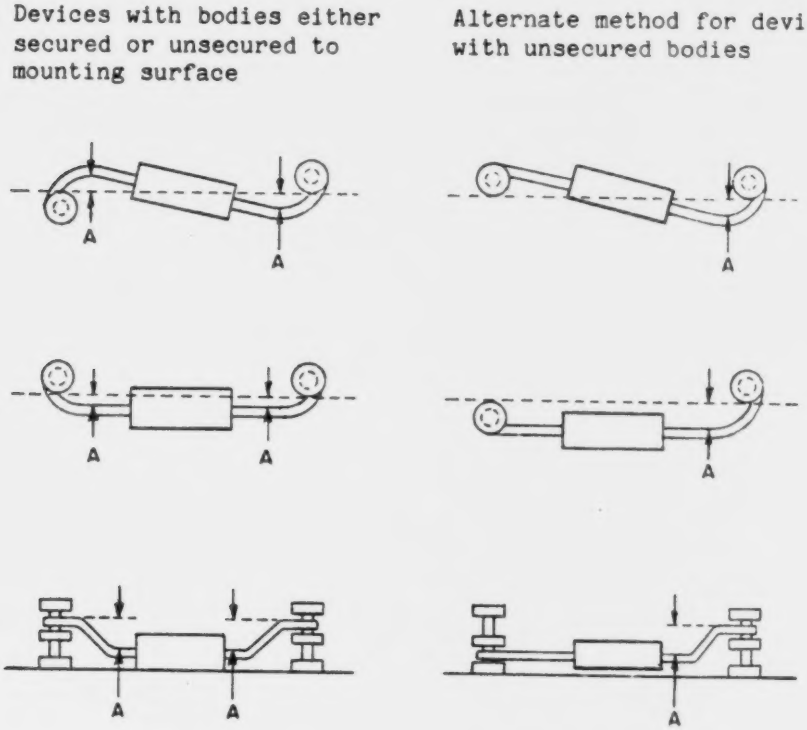


a. Standard Bend b. Welded Bend

LEAD DIA (inch)	MINIMUM RADIUS (R)
up to 0.027	1.0 D
from 0.028 to 0.047	1.5 D
0.048 and larger	2.0 D

Figure 5-2. Lead Bend

5.1.3 Stress relief. Axial or opposed lead devices with leads terminating at a connection point shall have a minimum lead-connection-to-body offset of at least 2 lead diameters or thicknesses (but not less than 0.030 inch) as an allowance for stress relief to minimize tensile or shear stress to the soldered connection or part during thermal expansion. Where the component body will not be secured to the mounting surface by bonding, coating or other means, the lead(s) on only one of the opposing sides of the component need be so configured. Typical examples of stress relief are included in figure 5-3.



A ≥ 2 times lead diameter or thickness but not less than 0.030 inch

Figure 5-3. Typical Stress Relief Bends

5.1.4 Insulation clearance. Clearance between the end of the insulation and the solder of the connection shall be as follows:

a. Minimum clearance: The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

b. Maximum clearance: Clearance shall be less than two wire diameters (including insulation) or 0.060 inch, whichever is larger, but shall not permit shorting between adjacent conductors.

5.2 Attachment of wires and leads directly to printed terminal areas. Direct attachment of wires and leads to printed terminal areas shall conform to MIL-STD-275 or MIL-P-50884, as applicable. Wire insulation clearance shall conform to 5.1.4.

6. Manual soldering

6.1 Precleaning. Cleanliness of part leads and printed wiring surfaces shall be sufficient to insure solderability.

6.2 Applying flux. When used, liquid flux shall be applied in a thin, even coat to those surfaces being joined prior to application of heat. Cored solder wire shall be placed in such a position that the flux can flow and cover the joint as the solder melts. Flux shall be so applied that no damage will occur to surrounding parts and materials.

6.3 Applying heat. The areas to be joined shall be heated to cause melting of the solder and wetting of the surfaces. Excessive time (slow heating) and excessive temperature shall be avoided to prevent unreliable joints and damage to parts. Heat sinks shall be used for the protection of parts, as required. Parts, wire insulation, or printed wiring boards which have been charred, melted, or burned shall be replaced. When heat has caused part materials to discolor, further evaluation shall be performed to ascertain whether the essential properties have been adversely affected; if so, the item shall be replaced.

6.4 Applying solder. The areas to be joined shall be at the correct temperature, then the solder shall be applied to the joint and not to the soldering iron; however, a very small quantity of solder may be applied at the place where the iron tip touches the joint to improve heat transfer. When the solder-preform method is used, the solder may be applied to the joint prior to heating.

6.5 Cooling. No liquid shall be used to cool a soldered connection. The connection shall be cooled in air at room temperature only. Heat sinks may be used to expedite cooling. The connection shall not be subjected to movement or stress at any time during the cooling and solidification of the solder.

6.6 Resoldering. Care should be taken to avoid the need for resoldering. When resoldering is required, the quality standards for the resoldered connection shall be the same as for the original connection. A cold solder or disturbed joint will require only reheating and reflowing of the solder.

6.7 Flux residue removal. Flux residues shall be removed within one hour after soldering by applying appropriate noncorrosive solvents, as specified in 4.2.a, and drying. Mechanical means such as agitation, brushing, etc, may be used in conjunction with the solvents. The cleaning solvents and methods used shall have no deleterious effect on the parts, connections, and materials being cleaned. Ultrasonic cleaning may damage certain parts, particularly transistors, and should generally be avoided.

7. Automatic soldering for printed wiring assemblies

7.1 Precleaning. Cleanliness of the part leads and printed wiring surfaces shall be sufficient to insure solderability.

7.2 Flux application. Liquid flux shall be applied by the dip, spray, brush, roll, wave, or foam method and shall form a thin coating on the surface. The flux may be thinned as necessary to meet the requirements on flux application; however, the flux shall still meet the requirements of 3.1. Drying the flux to a tacky consistency before wave soldering will prevent solder splatter.

7.3 Preheating. Preheating the printed wiring assembly before soldering is advisable and will improve solder flow and reduce the required dwell time. The preheat temperature shall not exceed the maximum temperature rating of parts.

7.4 Solder bath. The solder bath shall be maintained at a temperature of 232° to 288°C (450° to 550°F). The temperature and the time of contact between the assembly and the solder shall be dependent upon such factors as preheating, thickness of board, number of contacts or conductors, and the type of parts. The period of exposure of any printed wiring board to a solder bath shall be limited to a duration which will not cause damage to the board or parts mounted thereon. In no case shall the temperature or length of time be such as to cause damage to heat-sensitive parts. Periodic inspections of the solder bath shall be made to insure that contamination levels meet the requirements of 7.4.1b.

7.4.1 Maintenance of solder purity. To maintain the proper purity of solder, the following procedures shall be adhered to in wave soldering of printed wiring assemblies.

a. Before soldering a printed wiring board, all dross appearing on the surface shall be removed. To prevent contamination of the solder, stainless steel or polytetrafluoroethylene (TFE) shall be used for stirring solder and removing dross. Dross blankets may be used provided the blankets do not contaminate the solder.

b. If the amount of any individual contaminant or the total of contaminants listed exceeds the percentage specified in table 5-II, the solder shall be replaced or altered to be brought within specifications.

7.4.2 Inspection for solder purity. Solder in solder baths shall be chemically or spectrographically analyzed or renewed at the testing frequency levels shown in table 5-II, column B. These intervals may be lengthened to the eight-hour operating days shown in column C when the results of analyses provide definite indications that such action will not adversely affect the purity of the solder bath. If contamination exceeds the limits of table 5-II, intervals between analyses shall be shortened to those eight-hour operating days shown in column A or less until continued purity has been assured by analyses. Records containing the results of all analyses and solder bath usage shall be available to the procuring activity.

Table 5-II. Contamination Limits

Contaminant[1]	Solder Operation: Preconditioning (Lead/Wire Tinning)	Solder Operation: Ass'y Soldering[2] (Pot, Wave, Etc.)	Testing Frequency: 8 Hr Operating Day[3] A	B	C	Solder Joint Characteristic Guidelines (If Solder is Contaminated)[4]
Copper	.75	.30	15	30	30	Sluggish solder flow, solder hard and brittle
Gold	.50	.20	15	30	30	Solder grainy and brittle
Cadmium	.01	.005	15	30	60	Porous and brittle solder joint, sluggish solder flow
Zinc	.008	.005	15	30	60	Solder rough and grainy, frosty and porous High dendritic structure
Aluminum	.008	.006	15	30	60	Solder sluggish, frosty and porous
Antimony	.20 → .50	.20 → .50	15	60	120	Not enough: Solder crumbles into white powder after low temperature aging Too much: Solder brittle
Iron	.02	.02	15	60	120	Iron tin compound $FeSn_2$ is not solderable - Compound on surface presents resoldering problems
Arsenic	.03	.03	15	60	120	Small blister-like spots
Bismuth	.25	.25	15	60	120	Reduction in working temperature
Silver[5]	.75	.10	15	60	120	Dull appearance - retards natural solvent action
Nickel	.025	.01	15	60	120	Blisters, formation of hard insoluble compounds

Notes:
1. The tin content of the solder bath shall be from 59.5% to 63.5% tin and tested at the same frequency as testing for copper/gold contamination. The balance of the bath shall be lead and/or the items listed above.
2. The total of copper, gold, cadmium, zinc, and aluminum contaminants shall not exceed .4% for assembly soldering.
3. An operating day constitutes any 8-hour period, or any portion thereof, during which the solder is liquefied and used.
4. See paragraph 7.4.2.1.
5. Not applicable for Sn62 solder - limits to be 1.75 → 2.25 (both operations)

7.4.2.1 Guidelines. The information provided in the right column of Table 5-II is presented to assist in the monitoring of the soldering operation and may be used to indicate a need for increased frequency of testing, other than that shown in columns A, B, and C, to insure proper purity levels.

7.5 Flux residue removal. Flux residues shall be removed in accordance with 6.7.

7.6 Resoldering. The automatic soldering operation may be repeated once, provided that the reheating and resoldering does not introduce degradation of parts or printed wiring boards.

7.7 Touchup. Manual soldering as specified herein is permitted, if necessary, to remove solder projections, icicles, and bridges of solder, or to add solder to the part connection area. The quality standards for touchup shall be the same as for the original work.

8. Additional soldering procedures. It is not the intention of Requirement 5 to exclude other acceptable procedures for applying flux and solder in making soldered electrical connections. However, the methods used must produce completed solder joints equivalent to the acceptable joints described in this requirement. The following requirements apply: (See para 3, 4, 5, 6, 7, and appropriate subparagraphs.)

a. Preparation and cleanliness of parts and wires

b. Proper attachment of wires and leads

c. Materials - fluxes, solders, and cleaning solvents

d. Application of fluxes and solders

e. Temperature control

f. Postsoldering cleaning. Terminations made with devices having premeasured amounts of solder and type R or RMA flux encapsulated in a preformed, transparent, heat shrinkable, self-sealing insulating material do not require flux removal.

8.1 Typical procedures. The following are typical additional acceptable soldering procedures:

a. Dip (solder bath)

b. Hot-plate

c. Induction

d. Radiation

e. Hot-gas-blanket.

8.2 Soldering guns. Soldering guns shall not be used.

8.3 Steel wool. Steel wool shall not be used.

9. Definitions

9.1 Soldered connection. A soldered connection is an electrical connection which employs solder for bonding two or more metals with an alloy (solder).

9.2 Solder. Solder is a metallic alloy, usually of lead and tin, used to mechanically and electrically join metallic surfaces by solidification following the wetting action of the melted alloy.

9.3 Soldering. Soldering is a process in which metallic surfaces in close physical proximity are joined by the wetting and subsequent coalescence of liquid solder having a much lower melting point (generally below 204°C) than any of the metals being joined.

9.4 Terminals. A terminal is a tie-point device used for the purpose of making electrical connections. Solder type terminals in common use include: turret, bifurcated (slotted), hook, eye, tab, and solder cups.

9.5 Part lead. A part lead is a solid or stranded wire that serves as a connection and, in some cases, as mechanical support for small electronic parts or assemblies.

9.6 Lead extension. A lead extension is that part of a lead or wire that extends beyond the soldered connection.

9.7 Flux. Flux is a chemically active compound that is capable of promoting the wetting of metals with solder.

9.8 Wetting. Wetting is the free flow and spreading of solder on a metallic surface to form an adherent bond.

9.9 Cold solder joint. A cold solder joint is an unacceptable solder joint due to poor wetting and insufficient heat.

9.10 Rosin solder connection. A rosin solder connection is an unsatisfactory connection which contains entrapped flux.

9.11 Disturbed solder joint. A disturbed solder joint is an unsatisfactory connection resulting from relative motion between lead/wire and the terminal area during solidification of the solder.

9.12 Reflow soldering. Reflow soldering is a process for joining parts by tinning the surfaces, placing them together, heating until the solder fuses, and allowing to cool in the jointed position.

9.13 Dewetting. Dewetting is a condition which results when the molten solder has coated the surface and then receded leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film; basis metal not exposed.

9.14 Nonwetting. Nonwetting is a condition wherein a surface has contacted molten solder but the solder has not adhered to all of the surface.

9.15 Excessive solder. Excessive solder is a condition resulting in an unsatisfactory connection because the contour of the elements of the connection are completely obscured or the solder has overflowed beyond the confines of the connection area.

9.16 Solder projection. A solder projection is an undesirable protrusion from a solidified solder joint or coating.

9.17 Planar mounted devices. Terms that apply to flat or round leads of planar mounted devices are defined in figure 5-4.

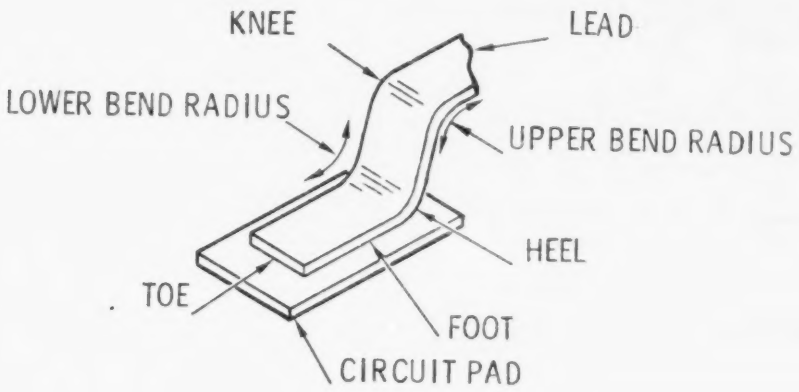
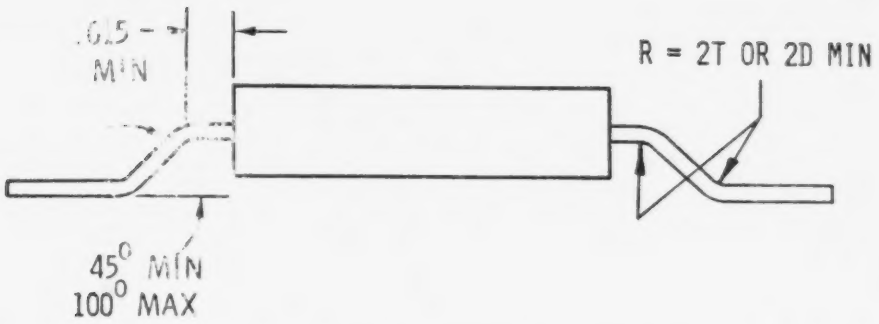


Figure 5-4. Planar Mounted Devices - Definitions

10. Workmanship. Workmanship shall be of a level of quality adequate to assure that the processed products meet the performance requirements of the applicable drawings and criteria delineated herein. The soldered connections shall have a smooth bright appearance with metallic luster and shall not have a chalky, gritty or irregular surface, nor exhibit protrusions, pits, or voids which expose basis metal or where the bottom of the pit or void is not visible.

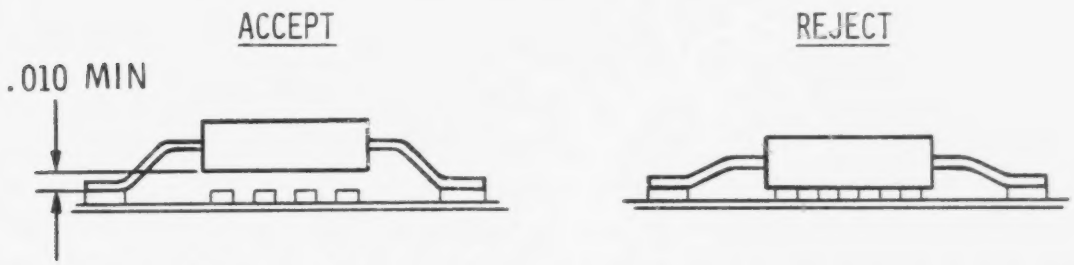
10.1 Inspection. Visual inspection of all soldered connections and assemblies shall be performed to determine conformance to the requirements specified herein.

11. Accept/reject criteria. Accept/reject criteria for soldered connections shall be in accordance with figures 5-5 through 5-35.



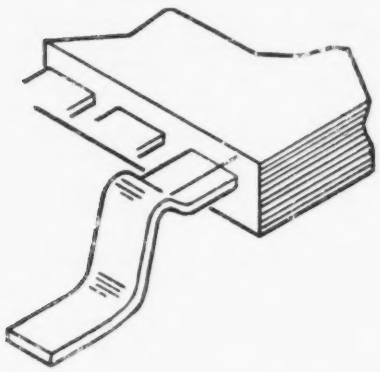
Leads shall be supported during forming to protect lead-to-body seal. Bends shall not extend into seal. Lead bend radius shall be two thicknesses or two wire diameters minimum. The angle of that part of the lead between the upper and lower bends in relation to the mounting pad shall be 45° minimum to 100° maximum.

Figure 5-5. Planar Mounted Devices - Lead Forming



Parts mounted over protected surfaces, or surfaces without exposed circuitry, may be mounted flush. Parts with electrically conducting bodies over exposed circuitry shall have their leads formed to allow a minimum of .010 inch between the bottom of the component body and the exposed circuitry.

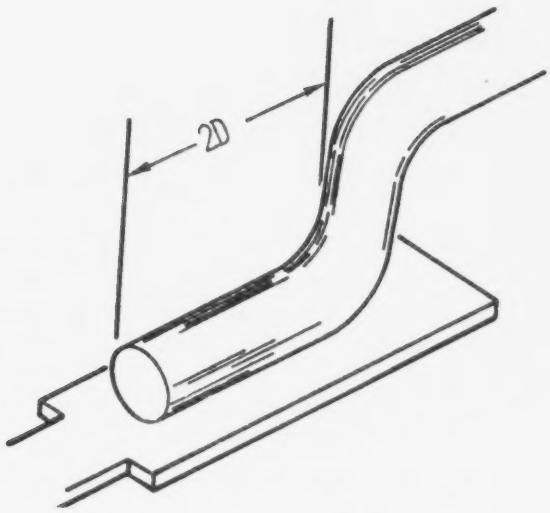
Figure 5-6. Planar Mounted Devices - Lead Forming



Minor lead deformation shall be allowed, provided none of the following conditions exist:

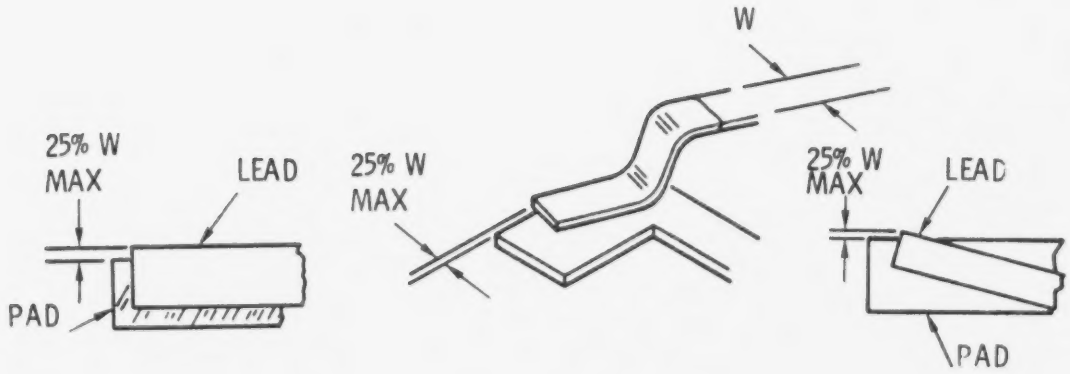
- No evidence of a short or potential short exists.
- Lead or body is not damaged by the deformation.
- Top of lead does not extend beyond top of body.

Figure 5-7. Planar Mounted Devices - Lead Forming



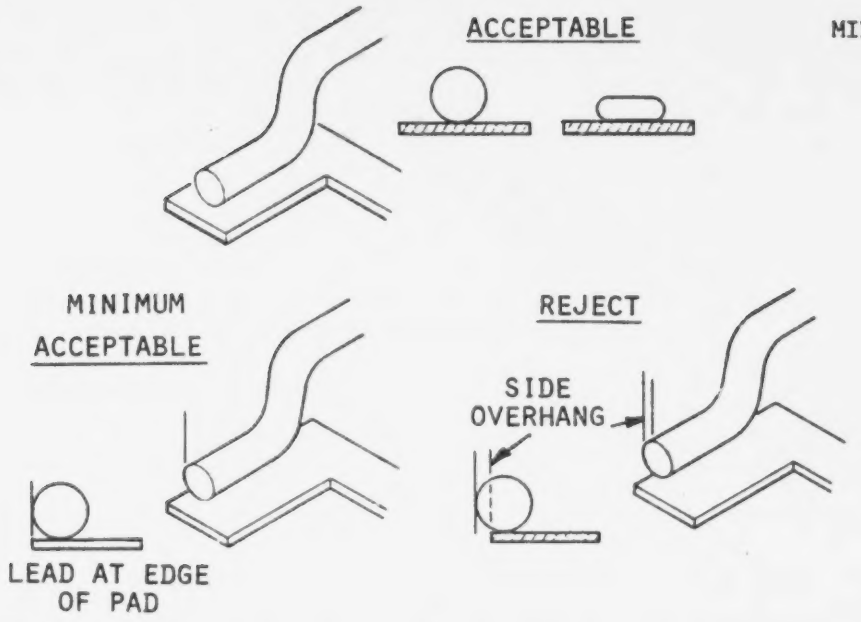
Minimum contact length shall be equal to the lead width for flat leads and two times the diameter (2D) for round leads. Heel must be completely over pad area.

Figure 5-8. Planar Mounted Devices - Part Placement



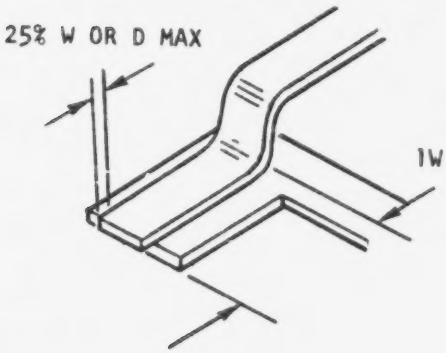
Flat leads may have side overhang, provided the overhang does not exceed 25% of the lead width and that minimum clearance is maintained.

Figure 5-9. Planar Mounted Devices - Part Placement



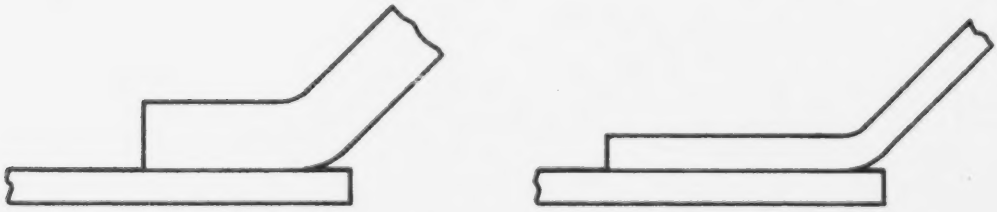
Round, flattened, or coined leads shall not exhibit any side overhang.

Figure 5-10. Planar Mounted Devices - Part Placement



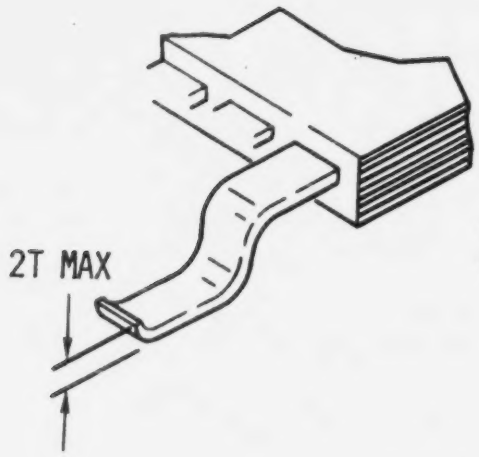
Toe end of leads may overhang the pad, provided the minimum conductor spacing is maintained, that the total overhang does not exceed 25% of the lead width or diameter (round leads), and that the minimum contact length is maintained.

Figure 5-11. Planar Mounted Devices - Part Placement



Round and flat leads shall be placed so that the heel does not extend beyond the edge of the pad.

Figure 5-12. Planar Mounted Devices - Part Placement

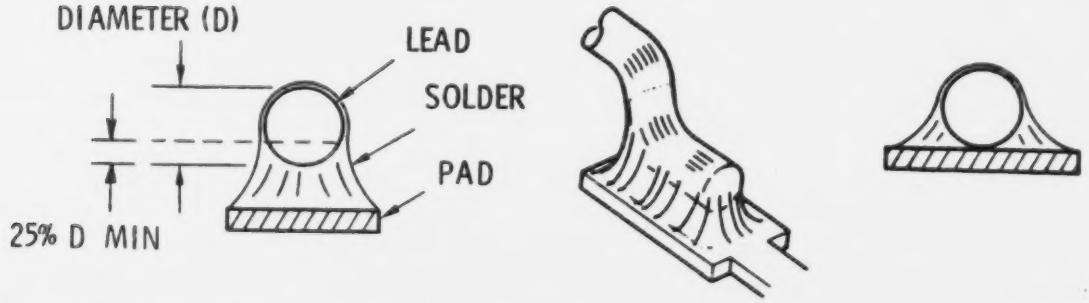


Toe curl, if present on leads, shall not exceed two times the thickness (2T).

Figure 5-13. Planar Mounted Devices - Part Placement

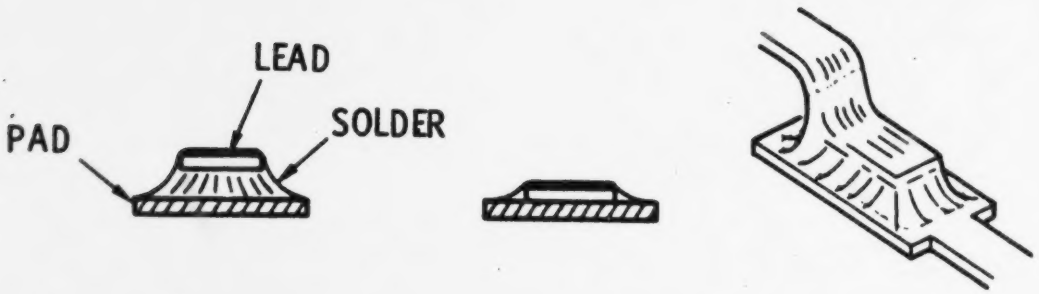
Lead may be raised off the pad surface a maximum of two lead thicknesses or 1/2 lead diameter.

Figure 5-14. Planar Mounted Devices - Part Placement



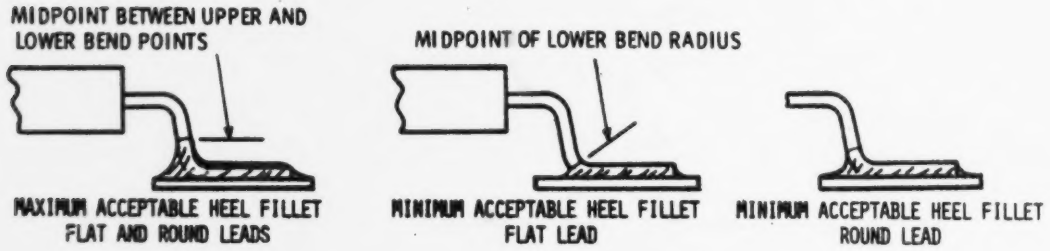
Minimum solder fillet height on round leads shall be 25% of the lead diameter. The outline of the lead must be discernible in the solder.

Figure 5-15. Planar Mounted Devices - Solder Fillets



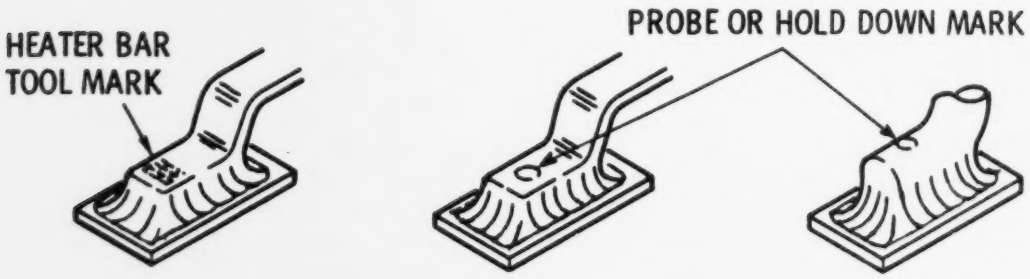
Flat leads shall exhibit a visible fillet rising from the pad to the top of the lead. The outline of the lead must be discernible in the solder.

Figure 5-16. Planar Mounted Devices - Solder Fillets


MIDPOINT BETWEEN UPPER AND LOWER BEND POINTS
MAXIMUM ACCEPTABLE HEEL FILLET FLAT AND ROUND LEADS
MIDPOINT OF LOWER BEND RADIUS
MINIMUM ACCEPTABLE HEEL FILLET FLAT LEAD
MINIMUM ACCEPTABLE HEEL FILLET ROUND LEAD

The heel fillet shall be continuous between the heel of the lead and the circuit pad. The heel fillet shall extend to the midpoint of the lower bend radius for flat leads. The heel fillet shall extend beyond the full bend radius for round leads. The solder fillet for any lead shall not extend beyond the midpoint between the upper and lower bend points.

Figure 5-17. Planar Mounted Devices - Solder Fillets



These tool marks shall not be cause for rejection.

Figure 5-18. Planar Mounted Devices - Solder Fillets

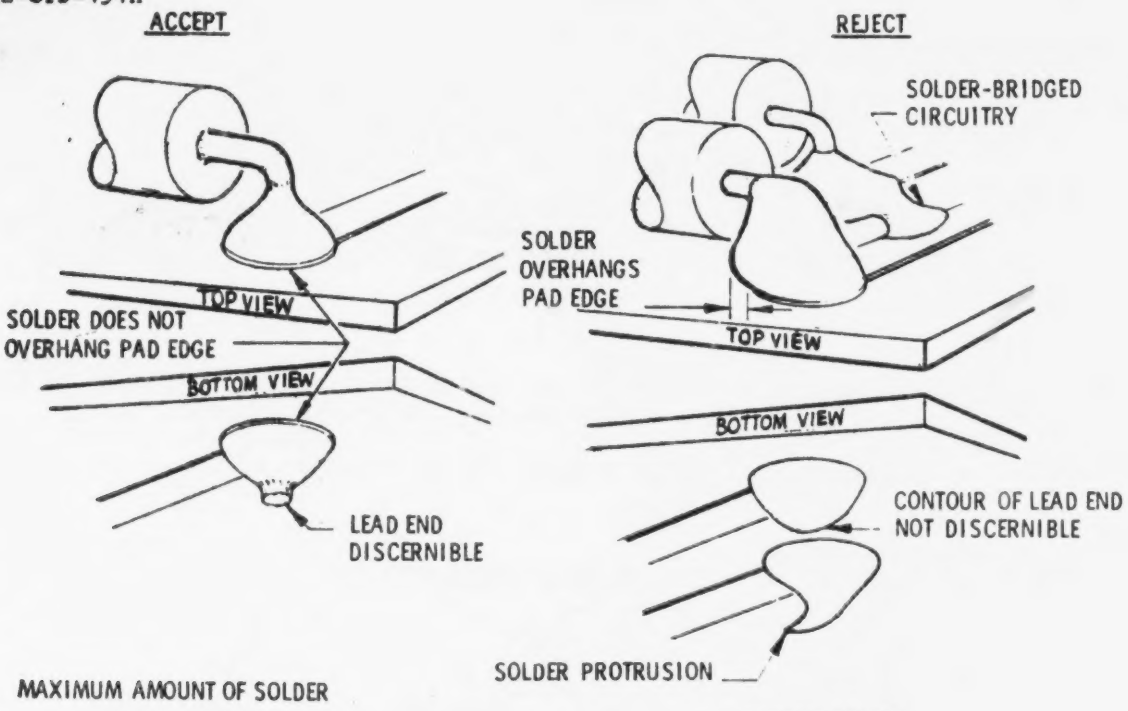


Figure 5-19. Plated-thru Holes - Amount of Solder on Joint

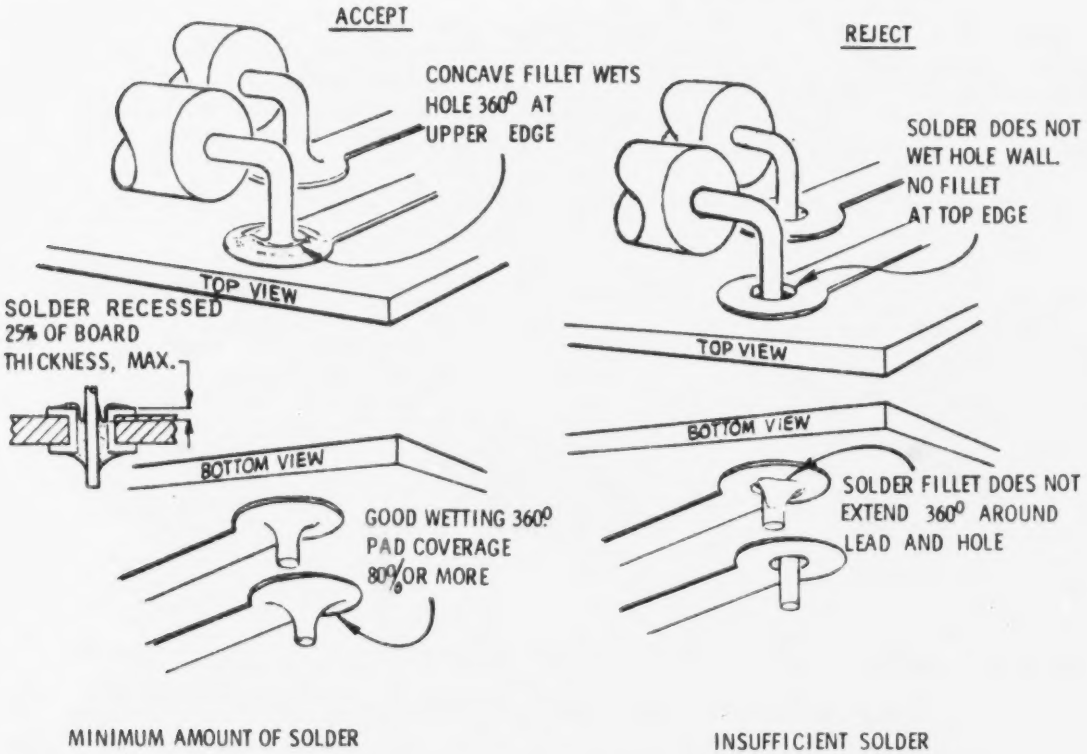
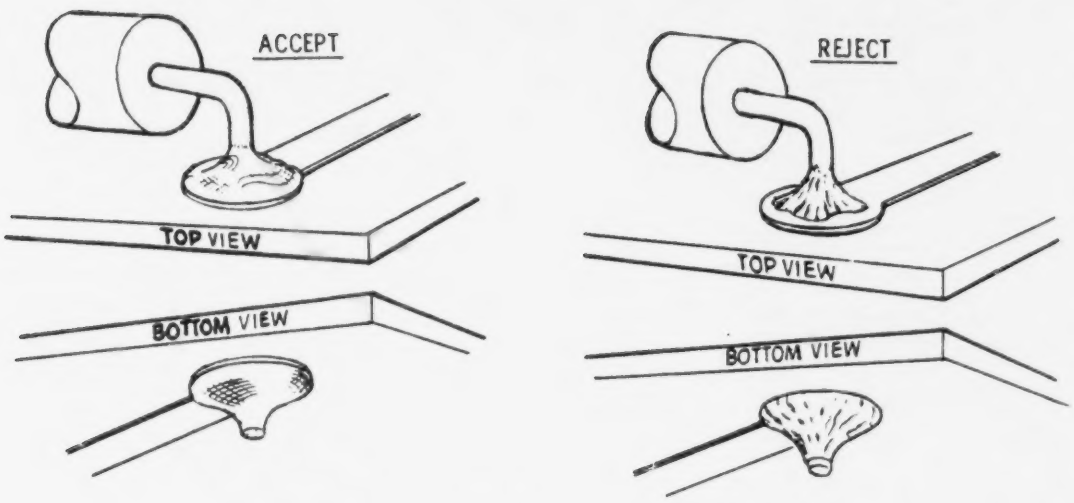

ACCEPT
REJECT
CONCAVE FILLET WETS HOLE 360° AT UPPER EDGE
SOLDER DOES NOT WET HOLE WALL. NO FILLET AT TOP EDGE
TOP VIEW
SOLDER RECESSED 25% OF BOARD THICKNESS, MAX.
BOTTOM VIEW
GOOD WETTING 360° PAD COVERAGE 80% OR MORE
SOLDER FILLET DOES NOT EXTEND 360° AROUND LEAD AND HOLE
MINIMUM AMOUNT OF SOLDER
INSUFFICIENT SOLDER

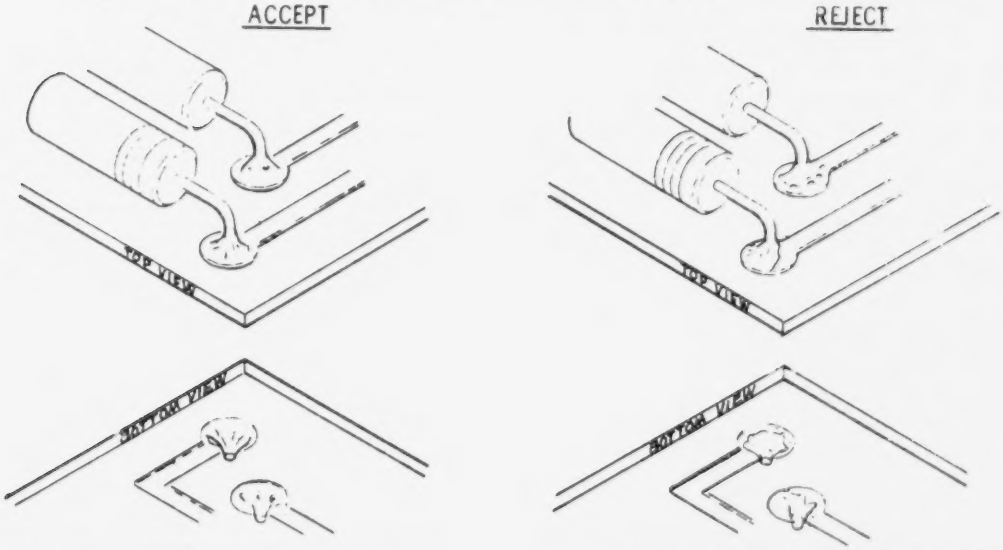
Figure 5-20. Plated-thru Holes - Amount of Solder on Joint



SATIN LUSTER AND FREEZE-LINE PATTERNS (QUILTING) PRESENT

SURFACE CRACKED, GRITTY OR GRANULAR APPEARANCE

Figure 5-21. Plated-thru Holes - Solder Surface Characteristics



SMALL INCLUSION IN FILLET DOES NOT CONSTITUTE DEWETTING.
SURROUNDING AREAS WELL WETTED.

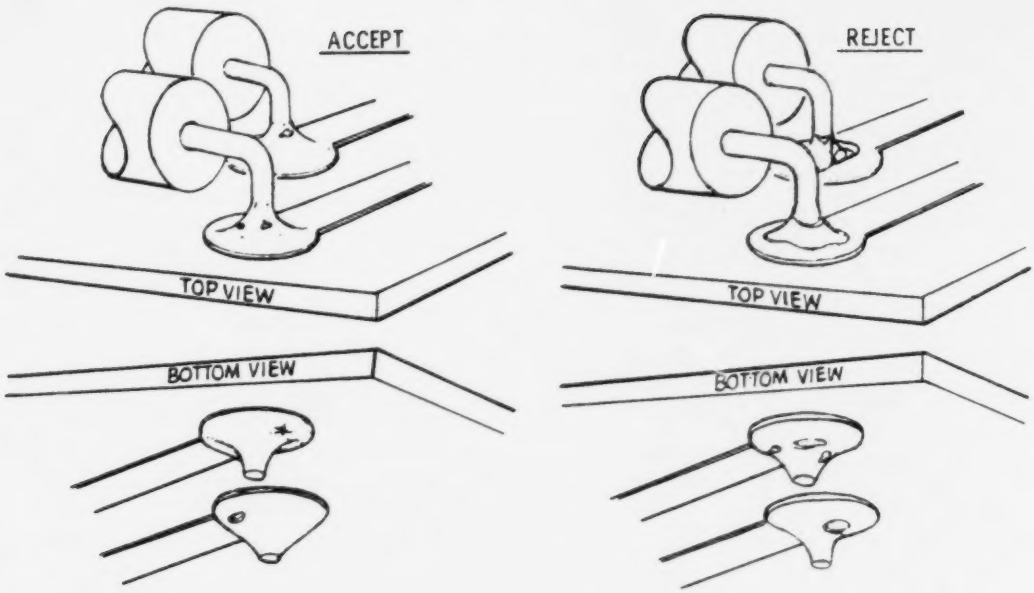
FILLET MAY BE CONCENTRATED ON ONE SIDE OF PAD.
NO DEWETTING IN EVIDENCE.

SOLDER DOES NOT COMPLETELY COVER SURFACES OR DOES NOT FEATHER TO LEAD OR PAD SURFACES.
SOLDER GATHERS INTO DROPLETS OR BALLS.

Figure 5-22. Plated-thru Holes - Solder Wetting

Supersedes
REQUIREMENT 5
30 June 1979

REQUIREMENT 5
15 March 1980



BOTTOM OF VOIDS VISIBLE

BOTTOM OF VOIDS NOT VISIBLE

Figure 5-23. Plated-thru Holes - Voids

MINIMUM ACCEPT

REJECT

SOLDER FILLET NOT COMPLETE.
NUMEROUS VOIDS.
EVIDENCE OF DEWETTING.

SOLDER FILLET 100% COMPLETE.
CONTOUR OF LEAD IS DISCERNIBLE.
HEEL OF LEAD IS WETTED WITH SOLDER.
SOLDER SHALL FILL HOLE 75% OF
BOARD THICKNESS MINIMUM.

EXCESS SOLDER. LEAD NOT VISIBLE.

Figure 5-24. Plated-thru Holes - Clinched Leads and Wires

MINIMUM ACCEPT

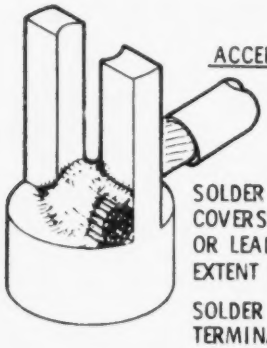
SOLDER FILLET 100% COMPLETE.
CONTOUR OF LEAD IS DISCERNIBLE.
HEEL OF LEAD IS WETTED WITH SOLDER.
NONPLATED THRU HOLE NEED
NOT BE COVERED WITH SOLDER.

REJECT

SOLDER FILLET NOT COMPLETE.
NUMEROUS VOIDS.
EVIDENCE OF DEWETTING.

EXCESS SOLDER. LEAD NOT VISIBLE.

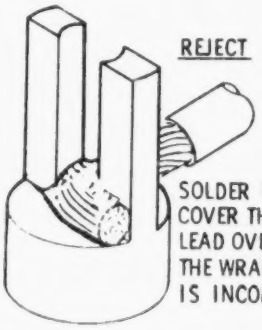
Figure 5-25. Nonplated-thru Holes - Clinched Leads and Wires



ACCEPT (MINIMUM)

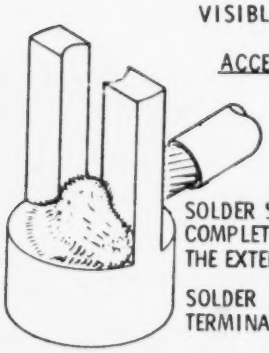
SOLDER THAT JUST COVERS THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP.

SOLDER SHALL WET THE TERMINAL AND WIRE OR LEAD AND FORM A VISIBLE FILLET.



REJECT

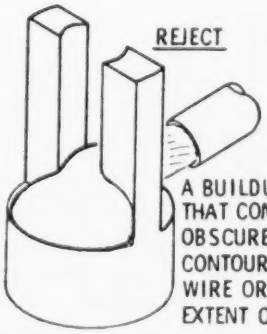
SOLDER DOES NOT COVER THE WIRE OR LEAD OVER EXTENT OF THE WRAP OR FILLETING IS INCOMPLETE.



ACCEPT (MAXIMUM)

SOLDER SHALL NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.

SOLDER SHALL WET THE TERMINAL WIRE OR LEAD.

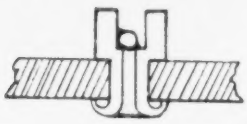


REJECT (EXCESSIVE)

A BUILDUP OF SOLDER THAT COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OR EXTENT OF THE WRAP.

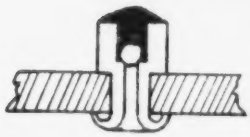
Figure 5-26. Wire and Lead Soldering to Terminals - Bifurcated

ACCEPT (MINIMUM)



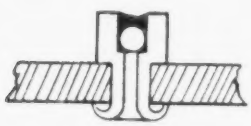
MINIMUM AMOUNT OF SOLDER ALONG THE WIRE OR LEAD. WIRE OR LEAD END DISCERNIBLE IN TERMINAL.

REJECT



SOLDER BUILDUP ON TOP OF TERMINAL. WIRE OR LEAD NOT DISCERNIBLE THROUGH TERMINAL.

ACCEPT (MAXIMUM)



MAXIMUM AMOUNT OF SOLDER COMPLETELY FILLS SLOT. WIRE OR LEAD END DISCERNIBLE IN TERMINAL.

Figure 5-27. Wire and Lead Soldering to Terminals - Small Slotted

ACCEPT (MINIMUM)

SOLDER THAT JUST COVERS THE WIRE OR LEAD OVER EXTENT OF THE WRAP.

SOLDER SHALL WET THE TERMINAL AND WIRE OR LEAD AND FORM A VISIBLE FILLET.

REJECT (INSUFFICIENT)

SOLDER DOES NOT COVER THE WIRE OR LEAD OVER EXTENT OF THE WRAP OR FILLETING IS INCOMPLETE.

ACCEPT (MAXIMUM)

SOLDER SHALL NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.

SOLDER SHALL WET THE TERMINAL AND WIRE OR LEAD.

REJECT (EXCESSIVE)

A BUILDUP OF SOLDER THAT COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OVER EXTENT OF THE WRAP.

Figure 5-28. Wire and Lead Soldering to Terminals - Turret

ACCEPT (MINIMUM)

SOLDER THAT JUST COVERS THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP.
SOLDER SHALL WET THE TERMINAL WIRE OR LEAD & FORM A VISIBLE FILLET.

REJECT (INSUFFICIENT)

SOLDER DOES NOT COVER THE WIRE OR LEAD OVER THE EXTENT OF THE WRAP OR FILLETING IS INCOMPLETE.

ACCEPT (MAXIMUM)

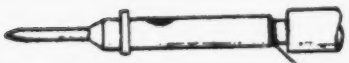
SOLDER SHALL NOT COMPLETELY OBSCURE THE EXTENT OF THE WRAP.
SOLDER SHALL WET THE TERMINAL & WIRE OR LEAD.

REJECT (EXCESSIVE)

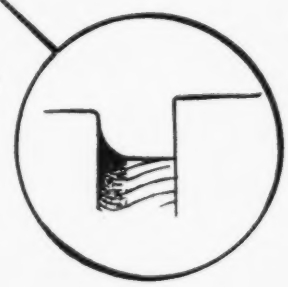
A BUILDUP OF SOLDER THAT COMPLETELY OBSCURES THE CONTOUR OF THE WIRE OR LEAD OR EXTENT OF THE WRAP.

Figure 5-29. Wire and Lead Soldering to Terminals - Hook

ACCEPT



SOLDER VISIBLE IN INSPECTION HOLE.
SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP VISIBLE.
ANY SOLDER ON THE OUTSIDE SURFACE OF THE SOLDER CUP IN THE FORM OF A THIN FILM ONLY.



REJECT

EXCESSIVE SOLDER AND SPILLAGE ON SIDE OF CONTACT.
SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP NOT VISIBLE.

SOLDER SLIGHTLY ABOVE INSPECTION HOLE.
SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP VISIBLE.

SOLDER NOT VISIBLE IN INSPECTION HOLE.
SOLDER WETTING BETWEEN WIRE OR LEAD AND CUP NOT VISIBLE.

Figure 5-30. Wire and Lead Soldering to Contacts

ACCEPT (MINIMUM)

SOLDER ALMOST FILLS CUP AND FOLLOWS THE CONTOUR OR THE CUP ENTRY.

WETTING BETWEEN LEAD OR WIRE AND CUP VISIBLE.

ANY SOLDER ON THE OUTSIDE SURFACE OF THE SOLDER CUP IN THE FORM OF A THIN FILM ONLY.

REJECT (INSUFFICIENT)

INSUFFICIENT SOLDER USED OR INSUFFICIENT WETTING.

ACCEPT (MAXIMUM)

SOLDER OVERFILLS CUP BUT DOES NOT OVERFLOW ON SIDES OF THE CUP.

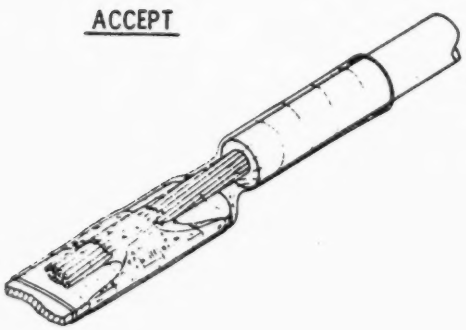
WETTING BETWEEN WIRE OR LEAD AND CUP IS VISIBLE.

REJECT (EXCESSIVE)

EXCESSIVE SOLDER, SOLDER HAS FLOWED ON SIDES OF CUP

Figure 5-31. Wire and Lead Soldering to Solder Cups

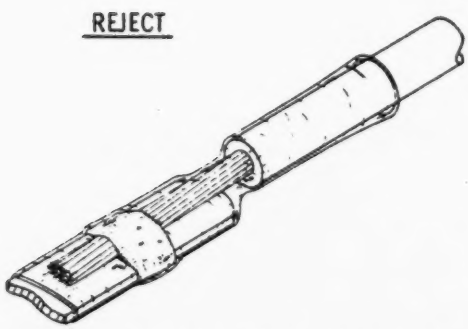
ACCEPT



MINIMUM SOLDER FLOW-- ACCEPT IF ALL OF THE FOLLOWING CONDITIONS ARE PRESENT:

SOLDER HAS LOST ALL APPEARANCE OF RING SHAPE.
THERE IS A DEFINITE FILLET VISIBLE ALONG THE TERMINAL AND LEAD INTERFACE.
TERMINAL AND LEAD CONTOURS ARE VISIBLE.

REJECT

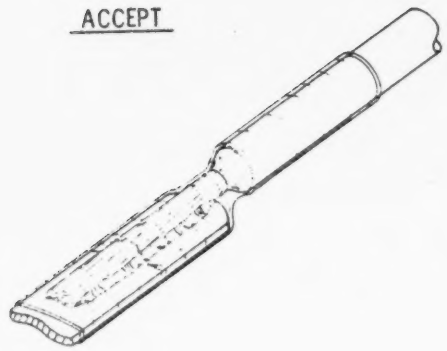


INSUFFICIENT HEAT-- REJECT IF ANY OF THE FOLLOWING CONDITIONS ARE PRESENT:

CONTOUR OF SOLDER PREFORM IS VISIBLE.
CONTOUR OF TERMINAL AND/OR LEAD IS OBSCURED BY SOLDER.

Figure 5-32. Heat Shrinkable Solder Devices - Connector Terminations

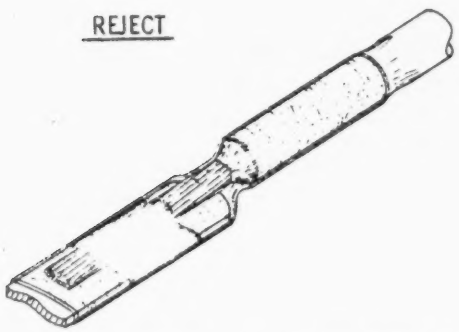
ACCEPT



MAXIMUM SOLDER FLOW-- ACCEPT IF ALL OF THE FOLLOWING CONDITIONS ARE PRESENT:

FILLET IS CLEARLY VISIBLE BETWEEN TERMINAL AND LEAD.
JOINT AREA IS VISIBLE DESPITE BROWNING OF SLEEVE.

REJECT

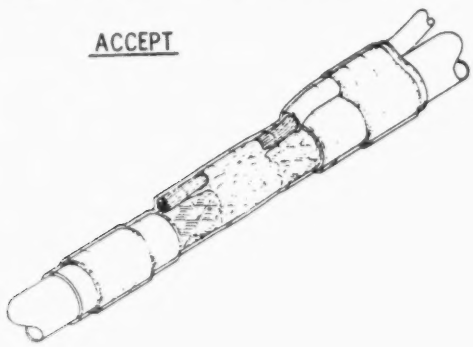


OVERHEATED-- REJECT IF ANY OF THE FOLLOWING CONDITIONS ARE PRESENT:

JOINT AREA IS NOT VISIBLE BECAUSE OF SEVERE DARKENING OF THE OUTER SLEEVE.
SOLDER FILLET IS NOT VISIBLE ALONG TERMINAL AND LEAD INTERFACE.
WIRE INSULATION DAMAGED (BROWNING OKAY) OUTSIDE OF THE SLEEVE.

Figure 5-33. Heat Shrinkable Solder Devices - Connector Terminations

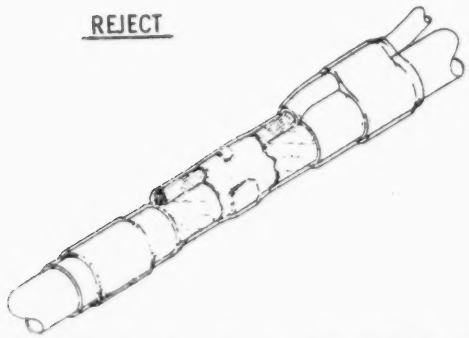
ACCEPT



MINIMUM SOLDER FLOW-- ACCEPT IF ALL OF THE FOLLOWING CONDITIONS ARE PRESENT:

SOLDER HAS LOST ALL APPEARANCE OF RING SHAPE.
INSERTS HAVE MELTED & FLOWED ALONG WIRES.
SHIELD & LEAD CONTOURS ARE VISIBLE.
THERE IS A DEFINITE FILLET VISIBLE ALONG THE LEAD AND SHIELD INTERFACE.

REJECT

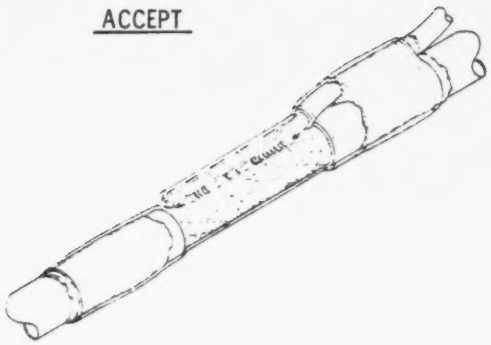


INSUFFICIENT HEAT-- REJECT IF ANY OF THE FOLLOWING CONDITIONS ARE PRESENT:

CONTOUR OF SOLDER PREFORM IS VISIBLE.
MELTABLE INSERTS HAVE NOT FLOWED.
CONTOUR OF BRAID AND/OR LEAD IS OBSCURED BY SOLDER.

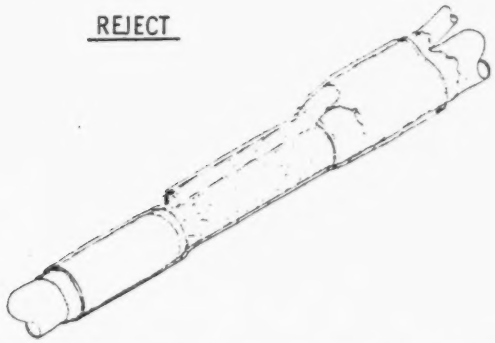
Figure 5-34. Heat Shrinkable Solder Devices - Shield Terminations

ACCEPT



MAXIMUM SOLDER FLOW-- ACCEPT IF ALL OF THE FOLLOWING CONDITIONS ARE PRESENT:
FILLET IS CLEARLY VISIBLE BETWEEN LEAD AND SHIELD.
JOINT AREA IS VISIBLE DESPITE BROWNING OF SLEEVE.

REJECT



OVERHEATED--REJECT IF ANY OF THE FOLLOWING CONDITIONS ARE PRESENT:
JOINT AREA IS NOT VISIBLE BECAUSE OF SEVERE DARKENING OF THE OUTER SLEEVE.
SOLDER FILLET IS NOT VISIBLE ALONG LEAD AND SHIELD INTERFACE.
WIRE INSULATION DAMAGED (BROWNING OKAY) OUTSIDE OF SLEEVE.

Figure 5-35. Heat Shrinkable Solder Devices - Shield Terminations

REQUIREMENT 6

BEARINGS

1. Purpose. This requirement establishes criteria for the selection and application of bearings.

2. Documents applicable to Requirement 6:

FF-B-171	Bearings, Ball, Annular (General Purpose)
FF-B-185	Bearings, Roller, Cylindrical; and Bearings Roller, Self-Aligning
FF-B-187	Bearing, Roller, Tapered
FF-B-195	Bearings, Sleeve, (Bronze, Plain or Flanged)
MIL-B-3990	Bearing, Roller, Needle, Airframe, Anti-friction
MIL-B-5687	Bearing, Sleeve, Washers, Thrust, Sintered, Metal Powder, Oil Impregnated
MIL-B-8942	Bearings, Plain, TFE Lined, Self-Aligning
MIL-B-8943	Bearings, Sleeve, Plain and Flanged, TFE Lined
MIL-B-8948	Bearing, Plain, Rod End, TFE Lined, Self-Aligning
MIL-B-13506	Bearing, Sleeve (Steel Backed)
MIL-B-17380	Bearing, Roller, Thrust
MIL-B-81744	Barrier Coating Solution, Lubricant Migration Deterring
MIL-B-81793	Bearing, Ball, Precision, for Instruments and Rotating Components
MIL-B-81934	Bearing, Sleeve, Plain and Flanged, Self-Lubricating
MIL-B-81936	Bearing, Plain, Self-Aligning (BeCu Ball, CRES Race)
MIL-STD-1334	Process for Barrier Coating of Anti-friction Bearings

3. Selection and application

3.1 Bearings. Bearings best suited to meet the physical, functional, environmental and service life requirements of the application shall be selected from those conforming to one or more of the specifications listed below. Replacement of the bearing shall be possible without the use of special tools unless such provisions would adversely affect the proper functioning or service life of the bearing.

FF-B-171	MIL-B-5687	MIL-B-17380
FF-B-185	MIL-B-8942	MIL-B-81793
FF-B-187	MIL-B-8943	MIL-B-81934
FF-B-195	MIL-B-8948	MIL-B-81936
MIL-B-3990	MIL-B-13506	

3.2 Lubricant. Adequate lubricant shall be provided either within the bearing or externally in the form of oil reservoirs or grease relubrication facilities except as noted in 3.6. Where lubricant replenishment is required, precautions shall be taken to prevent purged or lost lubricant from entering and adversely affecting the operation of the electronic equipment. Where bearings coated with preservative are installed in closed housings, the preservative shall be compatible with the lubricant used in the assembly.

3.3 Barrier coating. Bearings requiring a barrier coating shall be coated in accordance with MIL-STD-1334. Barrier coating material shall conform to MIL-B-81744.

3.4 Seals and shields. All rolling element bearings shall be adequately protected by seals or shields on the bearing or installed in housings which provide adequate shielding to prevent foreign matter from entering the bearing.

3.5 Self lubricating bearings. Permanently lubricated bearings or bushings of plastic, metallic-plastic combinations, or all metallic materials with or without dry film lubricants may be used provided wear products produced during operation will not cause or contribute to failure of the electronic equipment or bearings.

3.6 Unlubricated bearings. Unlubricated bearings or bushings may be used only in applications where the presence of a lubricant would be undesirable or detrimental and the functional, environmental and service life requirements can be met in this condition. For selection of low friction, long life, unlubricated bearings refer to MIL-B-8942, MIL-B-8943, and MIL-B-8948.

3.7 Electrical grounding. Ball and roller bearings used for rotating an electrically energized equipment shall be electrically shunted to avoid current flow through the bearings.

4. Alignment. Bearings shall be located to ensure proper shaft alignment and support.

REQUIREMENT 7

INTERCHANGEABILITY

1. Purpose. This requirement establishes criteria for the selection and application of interchangeable items.

2. Documents applicable to Requirement 7:

MIL-STD-280 Definitions of Item Levels, Item Exchangeability, Models, and Related Terms

3. Interchangeable items. Interchangeable items shall be as defined in MIL-STD-280 to permit their installation as interchangeable assemblies, subassemblies and parts without regard to the source of manufacture or supply.

4. Standard items. Standard items are defined in the applicable general specification.

4.1 Design tolerances. Provisions shall be made for design tolerances such that items having the dimensions and characteristics permitted by the item specification may be used as replacements without selection or departure from the specified equipment performance.

4.2 Use of standard items. Standard items shall be used when such items are available. When existing standard items are not available and permission is granted by the procuring activity for use of a nonstandard item only because the existing standard item is not available, the equipment shall be so designed that the nonstandard item can be replaced by the standard item. Appropriate space, mounting holes, and other necessary provisions shall be provided for this purpose unless they conflict with the specified equipment size requirement. When provision is made for substitute or replacement items, the standard item to be used for replacement shall be identified in the applicable documentation.

4.3 Choice of parts and materials. When the item specification provides more than one characteristic or tolerance, the item having the broadest characteristics and tolerances that will fulfill the equipment performance requirements shall be used. However, delays in development or production caused by procurement time required for such items may be avoided by substitution of readily available acceptable items of higher quality.

REQUIREMENT 8

ELECTRICAL OVERLOAD PROTECTION

1. Purpose. This requirement establishes the criteria and philosophy for electrical overload protection.

1.1 Classification. The requirements for electrical overload protection apply to electrical and electronic equipment intended for use in the following classes. The protection philosophy differs for each classification.

a. Class 1 equipment: Ground and shipboard, including test and checkout ground equipment.

b. Class 2 equipment: Manned aircraft, mannned spacecraft.

c. Class 3 equipment: Missiles, unmanned spacecraft, and drone-type craft.

2. Documents applicable to Requirement 8:

MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements

3. Application. The requirements specified herein shall apply only to equipment and systems as defined in MIL-STD-280 for class 1 and class 2 equipment and MIL-STD-1539 for class 3 equipment.

4. Protection for class 1 equipment

4.1 Current overload protection. Current overload protection for the equipment shall be provided by fuses, circuit breakers, or other protective devices for primary circuits.

4.2 Protective devices. Devices such as fuses, circuit breakers, time-delays, cutouts, or solid state current-interruption devices shall be used to open individual leads of a circuit whenever a fault occurs. Protective devices for wired-in equipment shall be connected to the load side of the equipment power switch (main circuit power disconnect). For portable equipment a separable connector or the attachment plug and receptacle shall serve as the main circuit power disconnect and the protective device may be on either the line side or the load side of the equipment on-off switch.

4.3 Network protection. Protection of individual parts from failure of associated parts should generally not be provided; however, protection of networks, such as pulse forming networks, from the failure of a single circuit by disconnecting this circuit from the network may be required.

4.4 Fuses. All fuses providing protection to the equipment shall be so located that they are readily replaceable and located in a convenient, serviceable location. Requirement for blown fuse indicators shall be as indicated in the detail equipment specification. Where fuses are used, at least one extra fuse of each type and rating used shall be supplied and

attached to the applicable units of the equipment. Panel-mounted fuse posts shall be such as to permit renewal of fuses without use of tools.

4.5 Circuit breakers. When circuit breakers are used, the restoring or switching device shall be readily accessible to the operator. The circuit breaker shall give a visual indication when the breaker is tripped. Holding the switching device closed on an overload shall not prevent tripping of the breaker. Multipole circuit breakers shall be used for three-phase equipment and shall disconnect all phases if an overload occurs in any one phase. Circuit breakers shall not be used as switches unless such breakers have been specifically designed and tested for that type service.

4.6 Normal performance. The use of overload or other protective devices shall not alter the normal performance characteristics of the source or load.

4.7 Secondary circuit. The use of protective devices in secondary circuits shall be held to a minimum. Cost and ease of replacement of the affected part or unit shall be included in the data used in determining the need for such protective devices.

5. Protection for class 2 equipment

5.1 Current overload protection. Current overload protection for the equipment shall be provided by fuses or circuit breakers to avoid hazards of fire, smoke, explosion and arc-over. Circuit breakers shall not be used as switches unless such breakers have been specifically designed and tested for that type service. In addition, overload protection of the primary power wiring to the equipment and internal wiring cable harnesses shall be provided. (Protection of the primary power wiring shall be provided by the vehicle contractor.)

5.2 Location. Overload protection for the equipment shall be provided therein. This protection shall be provided in the most advantageous portions of the circuits. All protective devices employed in the equipment shall be in a readily accessible, safe location therein.

5.3 Spare fuses. When fuses are used, a minimum of one spare fuse for each size and rating but a quantity of not less than 10 percent of the total shall be incorporated in the equipment and shall be contained in the same compartment as the used fuse.

5.4 Resettable circuit protectors. Circuit breakers or other resettable devices shall be used to protect critical circuits, or where predictable overloads or surges occur because of peculiar equipment functions or operator effects which are unavoidable. The reset controls of such devices shall be readily accessible to the operator.

5.5 Gap clearance. Fuses or circuit breakers shall have sufficient gap clearance, after breaking or clearing, to prevent arcing at any altitude at which the equipment will be required to operate.

6. Protection for class 3 equipment. Unless otherwise specified by the procuring activity, electrical overload protection shall not be provided in individual boxes or systems receiving power. Overload protection, when

required, shall be part of the missile, space booster, or spacecraft electrical power control subsystems and shall conform to the failure protection requirements of MIL-STD-1539.

REQUIREMENT 9

WORKMANSHIP

1. Purpose. This requirement establishes the acceptable workmanship criteria for electronic equipment intended for use by the Department of Defense. This requirement will define those workmanship requirements not normally covered in subsidiary specifications or drawings. It is not intended to supersede any of the provisions of the contract or applicable specifications and drawings considered a part of the contract. Where actual conflict exists, the provisions of the contract or application specification or drawing shall take precedence over the requirement herein.

2. General. Workmanship shall be in accordance with the requirements herein and any requirements of the detail equipment specification applicable to soldering, marking of parts and assemblies, wiring, welding and brazing, plating, riveting, finishes, machine operations, screw assemblies, and freedom of parts from burrs, sharp edges, or any other damage or defect that could make the part (or equipment) unsatisfactory for the purpose intended.

3. Mounting of parts. Parts or hardware shall be assembled and secured or mounted in the specified manner to satisfactorily accomplish the purpose for which intended. Electronic equipment having missing, inoperative, defective, bent, broken, or otherwise damaged parts will not be acceptable.

3.1 Mounted hardware installation. The installation of hardware parts, such as hinges, catches, handles, or knobs, shall be accomplished in such manner as to avoid damaging the hardware or the mounting surface. Hardware or mounting surfaces damaged in this way shall be touched up to provide a continuous protective coating. A color match between the surface touched up and the original finish shall be provided.

4. Cleaning. After fabrication, parts and assembled equipment shall be cleaned of smudges; loose, spattered, or excess solder; weld metal; metal chips and mold release agents or any other foreign material which might detract from the intended operation, function, or appearance of the equipment. (This would include any particles that could loosen or become dislodged during the normal expected life of the equipment.) All corrosive material shall be removed. Whenever possible, this cleaning shall take place before the parts are assembled into the equipment. All assembled equipment shall be cleaned of contaminants such as lubricating oils, mold release agents, waxes, sand, corrosion products, solder fluxes, finger prints, dust, etc. The nature of the contaminant must be determined to the extent that a suitable cleaning solvent can be selected for item removal. The inertness of the materials of construction to the solvent must be determined to prevent damage to electrical and mechanical properties. After cleaning, moving parts should be relubricated and the assembly allowed to dry to remove trapped or soaked cleaning fluid. Cleaning processes shall have no deleterious effect on the equipment or parts.

5. Threaded parts or devices. Screws, nuts and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs.

5.1 Tightness. All screw-type fasteners shall be tight. The word tight means the screw shall be firmly secured and that there shall be no relative movement possible between the attached parts.

6. Riveting. The riveting operation shall be carefully performed in order to assure that rivets are tight and satisfactorily headed with the rivet heads tightly seated against their bearing surface.

7. Gear assemblies. Gear assemblies shall be aligned and meshed and shall be operable without interference, tight spots, loose spots, excessive backlash, or other irregularities that could cause unsatisfactory operation.

8. Bearing assemblies. Bearing assemblies shall be free of rust, discoloration, and imperfections of ground, honed, or lapped surfaces. Contacting surfaces shall be free of tool marks, gouge marks, nicks, or other surface-type defects. There shall be no detrimental interference, binding, or galling.

9. Wiring. Insulated wire running between equipments or subassemblies within an equipment, such as between drawers or chassis and module subassemblies, shall be formed into cables or ducted wherever practicable. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges.

9.1 Wire dress or cabling of wires shall not result in improper electrical operation or interference with mechanical operation that will lead to subsequent damage of the wire or cable. Wires and cables subject to flexing shall be protected to prevent abrasion.

9.2 Lacing of cabling shall be neat in appearance. The lacing shall be applied firmly, yet not with excessive pressure which could cut into conductor insulation.

9.3 Cabling or wiring harnesses shall be anchored to avoid damage to conductors or adjacent parts.

9.4 Insulation. There shall be no evidence of burns, abrading, or pinch marks in the insulation that could cause short circuits or leakage.

9.5 Splicing. Wires in a continuous run between two terminals shall not be spliced during the assembly of the equipment, except where a stranded conductor is spliced to a solid conductor and the two are supported at the splice.

9.6 Clearance. The clearance between wires or cables and heat generating parts, such as electron tubes and resistors, shall be such as to avoid deterioration of the wires or cables from the heat dissipated by these parts under the specified service conditions of the equipment.

9.7 Shielding. Shielding on wires and cables shall be secured in a manner that will prevent it from contacting or shorting exposed current-carrying parts. The shielding shall terminate at sufficient distance from the exposed

conductors of the cable to prevent shorting or arcing between the cable conductor and the shielding. The ends of the shielding or braid shall be secured against fraying.

10. Welding and brazing. All welds and brazes shall be free of harmful defects such as cracks, porosity, undercuts, voids, and gaps. There shall be no burn-through. Fillets shall be uniform and smooth. Angular or thickness misalignment, warpage, or dimensional change due to heat from the operation shall be within permitted tolerances. There shall be no damage to adjacent parts resulting from the welding or brazing.

REQUIREMENT 10

ELECTRICAL CONNECTORS

1. Purpose. This requirement establishes criteria for the selection and use of electrical connectors.

* 2. Documents applicable to requirement 10:

MIL-J-641	Jack, Telephone, General Specification for
MIL-P-642	Plug, Telephone, and Accessory Screws, General Specification for
MIL-C-10544	Connector, Plug and Receptacle (Electrical, Audio, Waterproof, Ten Contact, Polarized)
MIL-C-12520	Connector, Plug and Receptacle (Electrical, Waterproof), and Accessories, General Specification for
MIL-C-55116	Connectors, Miniature, Audio, Five-Pin
MIL-C-55181	Connectors, Plug and Receptacle, Intermediate (Electrical) (Waterproof), General Specification for
MIL-A-55339	Adapter, Connector, Coaxial, Radio Frequency, General Specification for
MIL-C-83503	Connectors, Electrical, Flat Cable, Nonenvironmental, General Specification for
MIL-STD-1353	Use and Selection of Electrical Connectors
MIL-STD-1646	Servicing Tools for Electric Contacts and Connections, Selection and Use of
ANSI C83.12-1956	Cable Connectors for Audio Facilities for Radio Broadcasting, Requirement for

3. Selection. Selection and use of electrical connectors shall be in accordance with MIL-STD-1353 and as specified herein. Intended use information contained in the individual connector specifications shall be considered prior to making connector selections. Contact crimp, installing, and removal tools shall be in accordance with MIL-STD-1646 or as specified in the individual connector specifications. However, contractors may use tooling as recommended by the contact or tooling manufacturer provided that the finished crimp meets all of the performance requirements of the contact and connector specification. The variety of these tools required within a system shall be kept to a minimum. Maintenance instructions and other data supplied by the contractor shall list the military standard tools and contacts.

4. Audio-frequency and communication connectors, special purpose. Connectors conforming to MIL-C-10544 or MIL-C-55116 shall be used in audio frequency applications, such as head sets and chest sets excluding pilots' helmets. For low level, three wire and audio input circuits in fixed plant nontactical sound equipment, connectors conforming to ANSI C83.12 shall be used.

5. Connectors with thermocouple contacts. All connectors used in conjunction with thermocouples shall have their contact materials identified by one of the following methods:

a. Nameplate securely attached to each connector half or mounted on the panel-mounted receptacles.

b. By means of insulation sleeving or other markers designed for attachment around wire bundles. Markers shall be attached adjacent to the plug. Contact materials shall be identified with abbreviations in accordance with table 10-I.

Table 10-I. Abbreviations for thermocouple materials

Chromel	CR	Cobalt	CO
Alumel	AL	Tungsten Rhenium	W RE
Iron	FE	Tungsten	W
Constantan	CN	Iridium	IR
Copper	CU	Rhodium	RH
Platinum	PT	Iridium Rhodium	IR RH
Platinum Rhodium	PT RH	Molybdenum	MO
Rhenium	RE	Gold	AU

6. Heavy duty connectors

6.1 Power connectors (40-200 amperes). All power connectors for any ground application shall conform to Section 102 of MIL-STD-1353 and shall be used with heavy duty jacketed cable as specified on the insert standards.

6.2 Connectors for general purpose heavy duty applications and shipboard power applications shall conform to Section 102 of MIL-STD-1353. Connectors used for external applications shall be pressurized and waterproof in the mated and unmated condition in accordance with the requirements of Classes C or L. Connectors used internally (within a protective enclosure such as a shelter) may be in accordance with Class R provided waterproofing or pressurization is not a requirement for the application.

6.3 Right angle power and control. (Army only). In applications where right angle bend is required, center lock screw multicontact connectors shall conform to MIL-C-12520 and MIL-C-55181, as applicable.

7. Connectors, general utility. Polarized connectors are the preferred styles and shall be used where automatic grounding must be provided to insure safety to equipment and personnel. Connectors for general utility power applications shall conform to Section 106 of MIL-STD-1353.

8. Plugs and jacks (telephone type). Telephone type jacks and plugs shall conform to MIL-J-641 and MIL-P-642.

9. Test jacks. Test jacks shall conform to Section 105 of MIL-STD-1353.

* 9.1 Rf test points. Jacks or receptacles for use as rf test points shall be selected in accordance with paragraph 10.

* 10. Rf connectors. Rf connectors shall conform to Section 200 of MIL-STD-1353.

10.1 Rf adapters. Adapters used with rf connectors shall conform to MIL-A-55339.

11. Connectors for printed wiring. Printed circuit connectors shall conform to Section 104 of MIL-STD-1353.

12. Connector wiring. Not more than one wire shall be routed through any hole in the grommet of an environmentally sealed connector. Multiple conductors may terminate in a contact provided the sum of the circular mil areas of the conductors does not exceed the maximum circular mil area for which the contact is rated.

13. Extra contacts. The following requirements are applicable to all articles of equipment, except those such as dynamotors, inverters, indicating instrument (meters), encapsulated assemblies, printed circuits, and the like, in which it is unlikely that additional circuits will be required.

13.1 Quantity and location. Unused connector contacts or contact positions for external circuits shall be available for future use, and shall be located on the periphery (outer contacts) of the connector. The minimum quantity shall be as specified below:

Total number of used contacts in connector	Unused contacts or contact positions required (min)
1 thru 25	2
26 thru 100	4
101 or over	6

13.1.1 An extra connector shall not be used to meet this requirement without the approval of the procuring activity.

13.2 Size and rating of extra contacts. The size and rating of extra contacts shall be compatible with other contacts within the connector.

13.3 Crimp contact connectors. When crimp contact environmentally sealed connectors are used all contact positions shall be filled with contacts.

13.3.1 Sealing plugs. Sealing plugs shall be inserted in the grommet holes of unused contacts in environmentally sealed connectors.

13.4 Potted connectors. For potted connectors, each unused contact shall have a maximum gauge wire of 6 inches minimum length attached and identified with the contact designation for future use. For connectors external to the unit, the wire end shall be suitably capped to prevent moisture from entering the connector.

14. Protective measures. All unmated connectors shall be protected with metal or plastic caps or otherwise suitably protected during maintenance, storage and shipment. Protective caps specified by military specifications or military standards and designed for mating with specific connectors shall be used. Unmated connectors which may contain electrically "hot" circuits while in environmentally hazardous areas shall be covered with moistureproof and vaporproof caps. Connectors on enclosed cabinet mounted equipment need not be provided with protective caps unless an environmental hazard exists.

15. Potting. Potting materials shall conform to approved military specifications and shall not deteriorate in chemical, physical or electrical properties, under specified system/equipment environment.

16. Connectors for flat conductor cable. Connectors for use with flexible flat conductor cable shall conform to MIL-C-83503.

* 17. Fireproof connectors. Fireproof and firewall connectors shall be class K and shall conform to section 101 of MIL-STD-1353. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug shall be class K. If flame integrity only is necessary without the need for electrical continuity, a class K receptacle must be used, but the mating plug may be of any type and class. In all cases, the plug and receptacle shall be environment resisting.

REQUIREMENT 11

INSULATING MATERIALS, ELECTRICAL

1. Purpose. This requirement establishes criteria for the selection and application of electrical insulating materials.

2. Documents applicable to Requirement 11:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
MIL-I-10	Insulating Materials, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-P-79	Plastic Rod and Tube, Thermosetting, Laminated
MIL-I-631	Insulation, Electrical, Synthetic - Resin Composition, Nonrigid
MIL-P-997	Plastic Material, Laminated, Thermosetting, Electrical Insulation, Sheets, Glass Cloth, Silicone Resin
MIL-I-3158	Insulation Tape, Electrical, Glass-Fiber (Resin-Filled), and Cord, Fibrous-Glass
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Treated
MIL-I-3825	Insulating Tape, Electrical, Self-Fusing: For Use In Electronics, Communications, and Allied Equipment
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-T-13020	Tape, Rubber, Unvulcanized, Splicing and Molding (Tapes TL-317/U and TL-318/U)
MIL-P-15037	Plastic Sheet, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin
MIL-P-15047	Plastic-Material, Laminated, Thermosetting Sheets, Nylon Fabric Base, Phenolic-resin
MIL-I-15126	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive
MIL-I-17205	Insulation Cloth and Tape, Electrical, Glass Fiber, Varnished
MIL-I-18057	Insulation Sleeving, Electrical, Flexible, Glass Fiber, Silicone Rubber Treated
MIL-P-18177	Plastic Sheet, Laminated, Thermosetting, Glass Fiber Base, Epoxy-Resin
MIL-I-18746	Insulation Tape, Glass Fabric, Polytetrafluoroethylene Coated
MIL-P-19161	Plastic Sheet, Laminated, Glass Cloth Polytetrafluoroethylene Resin
MIL-I-19166	Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure Sensitive
MIL-I-22076	Insulation Tubing, Electrical, Nonrigid, Vinyl, Very Low Temperature Grade
MIL-I-22129	Insulation Tubing, Electrical, Polytetrafluoroethylene Resin, Nonrigid
MIL-P-22324	Plastic Sheet, Laminated, Thermosetting, Paper-Base Epoxy-Resin
MIL-I-23053	Insulation Tubing, Electrical, Heat-Shrinkable
MIL-I-23264	Insulators, Ceramic, Electrical and Electronic, General Specification for
MIL-I-23594	Insulation Tape, Electrical; High Temperature, Polytetrafluoroethylene, Pressure-Sensitive
MIL-I-24092	Insulating Varnish, Electrical, Impregnating
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive

MIL-I-46852 Insulation Tape, Electrical, Self Adhering, Unsupported Silicone Rubber
Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Ceramics. Ceramic materials shall conform to MIL-I-10.

3.1 Insulators, ceramic. Ceramic insulators shall conform to MIL-I-23264.

4. Cushions. Insulators shall be cushioned when required for protection against damage or breakage.

5. Insulating materials, electrical. Insulating materials shall be selected based on meeting or exceeding the use requirements, such as:

a. Temperature endurance
b. Moisture absorption and penetration
c. Fungus resistance
d. Dielectric strength
e. Dielectric constant
f. Mechanical strength
g. Dissipation factor
h. Ozone resistance.

5.1 Insulation classes. The insulation used shall be of such a class as to meet the temperature extremes to which it may be subjected, as specified in the detail equipment specification. Insulation classes and the maximum hotspot temperatures for continuous operation are as follows:

a. Class A - 105°C maximum
b. Class B - 130°C maximum
c. Class F - 155°C maximum
d. Class H - 200°C maximum
e. Class C - Above 200°C.

6. Electrical tape. Neither cotton nor linen tapes shall be used. Tape shall be selected from the types included in MIL-I-3158, MIL-I-3825, MIL-T-13020, MIL-I-15126, MIL-I-17205, MIL-I-18746, MIL-I-19166, MIL-I-23594, MIL-I-24391, and MIL-I-46852.

7. Sleeving. Sleeving shall provide adequate dielectric strength and leakage resistance under the designated service conditions. Sleeving shall conform to MIL-I-631, MIL-I-3190, MIL-I-7444, MIL-I-18057, MIL-I-22076, MIL-I-22129, or MIL-I-23053.

8. Plastic materials, general. Plastics used for electrical insulating parts shall combine properties of flame resistance, arc resistance, and low toxicity with good electrical and mechanical properties. Plastic parts shall retain the original smooth or polished surface unless objectionable or functional requirements make a dull surface more desirable. All surfaces that have been sawed, cut, or otherwise machined shall be reasonably smooth. If necessary for moisture resistance, the surfaces shall be sealed with a suitable material. No material which softens within the equipment storage or operating temperature range shall be used.

9. Plastic, thermosetting, cast. When used for electrical insulation, parts fabricated from cast thermosetting plastic materials shall be in accordance with L-P-516.

10. Plastic, thermosetting, laminated. When used for electrical insulation, parts fabricated from laminated thermosetting-plastic sheets, plates, rods, and tubes (except transparent plastics) shall be treated with a suitable material after all machining and punching operations have been completed. Materials having moisture absorption of 1.0 percent or less, and those used in hermetically sealed containers, need not be treated. Cotton or linen shall not be used as the base or filler for any laminated plastic requiring electrical properties. The preferred base is glass cloth. Materials selected shall conform to MIL-P-79, MIL-P-997, MIL-P-15037, MIL-P-15047, MIL-P-18177, MIL-P-19161, or MIL-P-22324.

11. Plastic, thermosetting, molded. Materials used to mold electrical insulators shall conform to MIL-M-14. Molded parts which undergo subsequent machining shall be vacuum impregnated with a suitable material and dried after all surface-breaking operations have been completed. Cotton and linen shall not be used as filler material in any electrical insulator. Materials having moisture absorption of 1.0 percent or less, and those used in hermetically sealed containers, need not be impregnated.

12. Varnish, insulating. When used for impregnation, insulating varnish shall be handled by a method which will insure removal of all air and water and insure a complete fill. Insulating varnish shall conform to MIL-I-24092.

13. Wire insulation. Wire insulation with cotton or linen in its construction shall not be used, except when the wire is used for coils on forms, and then only provided the insulation on the wire is completely sealed off from the atmosphere.

14. Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

15. Polyvinyl chloride. Polyvinyl chloride insulating materials shall not be used in manned aerospace applications.

REQUIREMENT 12

FASTENER HARDWARE

1. Purpose. This requirement establishes criteria for the selection and application of fastener hardware.

2. Documents applicable to Requirement 12:

FF-B-575	Bolts, Hexagon and Square
FF-N-836	Nut, Square, Hexagon, Cap, Slotted, Castellated, Clinch, Knurled and Welding
FF-R-556	Rivet, Solid, Small; Rivet, Split, Small; Rivet Tubular, Small; and Caps, Rivet, General Purpose
FF-S-85	Screw, Cap, Slotted and Hexagon-Head
FF-S-86	Screw, Cap, Socket-Head
FF-S-92	Screw, Machine; Slotted, Cross Recessed or Hexagon Head
FF-S-107	Screws, Tapping and Drive
FF-S-200	Setscrews; Hexagon Socket and Spline Socket, Headless
FF-S-210	Setscrews, Square Head and Slotted Headless
FF-W-84	Washers, Lock (Spring)
FF-W-92	Washer, Metal, Flat (Plain)
FF-W-100	Washer, Lock (Tooth)
QQ-P-416	Plating, Cadmium (Electrodeposited)
TT-S-1732	Sealing Compound, Pipe Joint and Thread, Lead Free General Purpose
FED-STD-H28	Screw-Thread Standards for Federal Services
MIL-S-1222	Studs, Continuous Thread (Bolt Studs); Nuts, Plain, Hexagon; and Steel Bars, Round - High Temperature Service
MIL-F-5591	Fasteners, Panel
MIL-R-5674	Rivets, Aluminum and Aluminum Alloy
MIL-B-6812	Bolt, Aircraft
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-B-7838	Bolt, Internal Wrenching, 160 KSI FTU
MIL-R-7885	Rivets; Blind, Structural, Pull-Stem and Chemically Expanded
MIL-R-8814	Rivets, Blind, Nonstructural Type
MIL-B-8831	Bolt, Tensile, Steel, 180 KSI Ftu, 450oF, External Wrenching, Flanged Head
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-T-10727	Tin Plating, Electrodeposited or Hot-Dipped for Ferrous or Nonferrous Metals
MIL-F-18240	Fastener, Externally Threaded 250oF, Self-Locking Element for
MIL-T-22361	Thread Compound, Antiseize, Zinc Dust-Petrolatum
MIL-S-22473	Sealing, Locking and Retaining Compounds, Single-Component
MIL-F-22978	Fastener, Rotary, Quick-Operating, High Strength
MIL-R-24243	Rivet, Blind, Nonstructural, Retained Mandrel, General Specification for
MIL-N-25027	Nut, Self-Locking 250oF, 450oF, and 800oF, 125 KSI FTU, 60 KSI FTU, and 30 KSI FTU
MIL-R-27384	Rivet, Blind, Drive Type

MIL-S-46163	Sealing, Lubricating, and Wicking Compounds, Thread Locking, Anaerobic, Single Component
MS33522	Rivets for Blind Attachment, Self-Plugging and Chemically Expanded Types, Limitations for Design and Usage
MS33540	Safety Wiring, and Cotter Pinning, General Practices for
MS33557	Nonstructural Rivets for Blind Attachment, Limitations for Design and Usage
NAS498	Bolts, Shear
NAS547	Fastener, Rotary, Quick-Operating, High Strength

3. Definitions. The following definitions apply to Requirement 12.

3.1 Fastener. A fastener is a mechanical device for holding two or more items or pieces of material together.

3.1.1 Fastener, self-locking. A self-locking fastener is a fastener with a prevailing-torque feature that resists rotation by gripping the mating thread.

3.2 Bolts and screws. Bolts and screws, as used herein, refer to the general classification of externally threaded headed fasteners.

3.3 Stud. A stud is a headless fastener which is completely or partially threaded with an external thread, and has no specific locking or wrenching provisions.

3.4 Nut. A nut is a fastening device having an internal thread or an aperture of lugs or prongs designed to mate with an external thread for the purpose of holding threaded members with which it is engaged.

3.5 Rivet. A rivet is a headed fastening device of malleable material with the shank end designed to be expanded, upset, or spread.

3.6 Positive holding device. A positive holding device is one that requires unlocking or destruction in order to remove the part it holds.

3.7 Soft material. Any plastic material, or any metal not in a work-hardened or case-hardened condition and having a Brinell hardness rating of less than 86, is a soft material.

3.8 Screw, self-tapping. Self-tapping screws are defined as follows:

a. Thread-cutting screw. An externally threaded fastener whose thread is interrupted by flutes or slots for the purpose of cutting its own mating thread.

b. Thread-forming screw. An externally threaded fastener whose thread is designed to form its own mating thread.

3.9 Screw, drive. A drive screw is a hardened cylindrical fastener with multiple spiral flutes on its shank. It also has an end smaller in diameter than the outside diameter of the spiral flutes which acts as a pilot when driven into a drilled hole.

3.10 Brittle material. A nonmalleable, nonelastic substance which cracks when deformed.

4. General. Fasteners shall be selected so as to remain secure when exposed to equipment operational and environmental stresses, including specified testing. Except for those items designed to be affixed with one fastener, parts shall be secured in such manner that failure of a single fastener will not free the part completely. When practicable, friction between mating surfaces shall not be employed as the sole means of preventing fixed parts from rotating or shifting. For critically stressed applications suitable torque values for screw thread assemblies shall be established and torque measuring or controlling devices shall be used for tightening the threaded parts.

5. Securing of parts. Securing of parts by threaded fasteners to materials other than wood shall be in accordance with the methods outlined in the following subparagraphs.

5.1 Mounting of soft material to soft material. The mounting or assembly of parts made of soft material to soft material shall be accomplished by one of the following means, where practicable:

a. A through-screw secured by a self-locking nut or plain nut and lock washer.

b. A through-screw secured by a plain nut, with a sealant applied to the threads of the screw and nut.

c. A screw in a threaded bushing; in a staked, clinched, or pressed-in nut; or in an insert. The bushing, nut, or insert shall be secured to the structure. Wherever practicable, the engaged length of threaded inserts should be at least 1-1/2 times the nominal diameter of the thread. (Where insert design makes this impossible, the requirements of paragraph 11 apply.) Where the material thickness is not great enough to accommodate a 1-1/2 times diameter insert, a shorter insert may be used if thread wear rather than strength is of primary importance, or a solid bushing type shall be used, which provides equal strength with less length because of the greater diameter. When an externally threaded fastener must be screwed into an aluminum alloy part and the parts must be frequently disassembled in service, the aluminum alloy parts shall be provided with inserts of corrosion-resistant steel or other suitable material. Threaded holes in plastic material, when used with externally threaded fasteners, shall be provided with suitable metallic inserts. When a lockwasher or a self-locking insert, nut, or bushing is not used, a sealant shall be applied to the threads of the bolt or screw and insert, nut, or bushing.

d. A screw in a tapped hole, with a sealant applied to the threads of the screw.

e. A stud in a tapped hole.

NOTE: The use of threaded fasteners made of aluminum alloy or magnesium to mate with threaded parts of aluminum alloy or magnesium shall be avoided wherever possible. Where such is required, an antiseize compound shall be used to prevent seizing of the threads.

5.1.1 Flat washers shall be used for the following applications:

a. Between screw heads and soft materials, unless a washer head screw, or similar type that provides a bearing surface equivalent to the bearing surface of the appropriate flat washer, is being used.

b. Between a nut or lockwasher and a soft material.

c. Where lockwashers are used for securing a soft material, a flat washer shall be provided to prevent marring or chipping of the material or the applied protective coating, except in areas where an electrical ground is required.

d. Except where it conflicts with electromagnetic interference considerations, a flat washer shall be used between an organically finished material and lock-washers, bolt and screw heads, or nuts.

5.2 Mounting of hard material to soft material. In addition to the methods outlined in 5.1, a screw with a lockwasher in a threaded bushing, insert, or tapped hole may be used.

5.3 Mounting of soft material to hard material. In addition to the methods outlined in 5.1, other means which may be used are:

a. A self-locking screw in a hole tapped into the hard material.

b. Self-tapping screw into the hard material when used within the limitations of paragraph 10.

5.4 Mounting of hard material to hard material. Any of the methods outlined in 5.1 through 5.3 may be used.

5.5 Fastening of brittle materials. Brittle castings or parts made of ceramic or other brittle material shall be properly cushioned when necessary to prevent breakage. Washers or gaskets of suitable material and compressibility shall be used between the otherwise facing surfaces of the brittle part and other brittle or metal parts, when practicable, to prevent breakage or damage to the protected parts during assembly or from severe shock, vibration or temperature changes encountered under the specified service conditions. Lead washers shall not be used.

5.5.1 Threaded devices securing parts mounted with pliable washers shall not depend upon lockwashers as a locking device. Threaded holes in ceramic material shall be avoided for assembly or mounting of parts, if possible.

6. Rivets

6.1 Application. Rivets shall be used, where practicable, in preference to other hardware for securing parts not requiring removal when the equipment is serviced. Rivets shall not be used for mounting items normally subject to replacement, such as capacitors, resistors, transformers, inductors, or tube sockets. Wherever the thickness of metal which accepts the heads of flush rivets is less than the height of the rivet heads, the material shall be dimpled rather than countersunk. Where practicable, the distance from the center of

rivet holes to the edges of the material in which the rivets are placed shall not be less than 1-1/2 times the rivet diameter. Rivets for joining magnesium parts shall be composition 5056 anodized aluminum alloy or an aluminum alloy having equal galvanic compatibility with the magnesium. Where applicable, design and limitations of rivets shall be in accordance with MS33522 and MS33557.

6.2 Selection. Rivets shall conform to one of the following specifications:

a. Small solid, split, tubular and general purpose rivets shall conform to FF-R-556.

b. Aluminum and aluminum alloy rivets shall conform to MIL-R-5674.

c. Nonstructural blind rivets shall conform to MIL-R-8814.

d. Structural blind, pull-stem rivets shall conform to MIL-R-7885.

e. Blind, drive type rivets shall conform to MIL-R-27384.

f. Blind, nonstructural, retained mandrel type rivets shall conform to MIL-R-24243.

7. Control shafts and couplings. Wherever the proper functioning of devices is dependent upon maintaining a prescribed relationship between control shafts and associated couplings, collars, gears, and similar parts not permanently fastened to the shaft, such parts shall be secured by positive locking devices. Keyed or splined parts shall be axially restrained if such movement would be detrimental to the operating characteristics. Appropriate set screws may be used for axial restraint. Light-duty items, such as indicator mechanisms and other devices normally designed to use friction locking means for adjustment, are exempted from this requirement. Socket style set screws are preferred.

7.1 Set screws. One set screw may be used on a flatted shaft. Two set screws at 90° to 120° displacement shall be used when the shaft is not flatted. Cone-point set screws shall not be used, except when the opposing metal has been properly countersunk to receive the cone-point.

8. Access devices (panels, doors, covers, and plates). The type, design, and spacing of the fastening devices used to retain access devices shall be consistent with the desired degree of closure and frequency of required access.

8.1 Screws and bolts for access devices. If used, screws and bolts shall be self-aligning, of the captive type when practicable. It shall be possible to remove the fasteners for replacement without damaging the attached panel or access door.

8.2 Quarter-turn fasteners. Quarter-turn fasteners shall be used only to retain nonstructural access devices where quick access is necessary. These fasteners shall conform to MIL-F-5591.

8.3 Quick access. Rotary, quick-operating, high strength panel fasteners such as those conforming to MIL-F-22978 or NAS 547 shall be used to retain structural access devices where quick access is necessary.

9. Countersinking. Fasteners should not normally be countersunk in sheet material having a thickness less than 1-1/2 times the height of the fastener head (in no case shall a feather edge be created). Thinner material should be dimpled to assure proper seating, with the fastener head edge flush with or below the surface of the material.

10. Thread-forming, thread-cutting, and drive screws. Thread forming, thread-cutting, and drive screws shall not be used except as follows:

a. For the permanent attachment of name plates to sheet metal where it is practicable to extrude the hole permitting a minimum 1/8-inch full-thread engagement.

b. With the specific approval of the procuring activity, thread-forming screws may be used on equipment to be installed in a static (fixed station) environment for low-stress applications where disassembly is not normally anticipated.

c. For the permanent attachment of nameplates to material having nominal thickness of 1/8-inch or greater.

11. Thread engagement. For highly stressed applications, screws or bolts shall have a minimum thread engagement of 1-1/2 times their nominal diameter in tapped parts other than nuts. In normal applications, screws or bolts shall have a minimum engagement length equal to their nominal diameter in tapped parts other than nuts. When the assembly is not frequently disassembled and where maximum stength is not required, less thread engagement may be used, provided special provisions are made to insure compliance with required conditions.

12. Lengths. The length of the screws and bolts installed with nuts shall be such that the exposed portion is a minimum of 1-1/2 threads. Maximum length shall be limited by the nearest larger standard screw length. These rules apply except when such projection will result in corona discharge or when design requirements cannot be met.

13. Locking devices. All threaded assemblies shall be vibration and shock proof.

13.1 Whenever practicable, where frequent disassembly (more than 15 times) is not expected, self-locking nuts shall be used in lieu of lockwashers.

13.1.1 Self-locking nuts shall be avoided on stud-mounted components unless the stud material is compatible with the strength or material of the nut used.

13.2 In applications requiring the use of bolts or screws without nuts, one of the following locking devices or methods shall be used:

a. Lockwashers under the heads of the bolts or screws

b. Self-locking screws

c. Self-locking thread inserts

d. A locking or retaining compound applied to the threads

e. Safety wire through drilled heads.

13.3 Castellated nuts with cotter pins are acceptable.

13.4 Flat head screws, when not secured by other locking means, shall be secured by the application of a retaining compound. Staking by means of upsetting metal is acceptable for permanent assemblies when other means are impracticable or unsatisfactory for design reasons.

13.5 Retaining compound or nonmetallic retaining devices in screws or nuts shall not be used where the specified service conditions or processing, such as baking of paints or soldering, might deteriorate the material. Retaining compounds which exceed the strength of the fastener shall not be used where disassembly is required.

14. Threaded fasteners and related parts

14.1 Threads. Threads shall be in accordance with FED-STD-H28 or MIL-S-7742. Where threaded fasteners are required to mate with or mount threaded commercial equipment or devices, threads shall be in accordance with FED-STD-H28. Threads shall be in accordance with MIL-S-8879 for applications requiring high stress or high fatigue life. (Caution shall be exercised where a MIL-S-8879 UNJ external thread fastener is used due to its incompatibility with the commonly used UNC, UNF, or UNEF threaded nut or tapped hole.)

14.1.1 Threads for airborne applications. Threaded parts for airborne applications shall be in accordance with MIL-S-7742 and as amplified below:

a. Threads for screws, bolts, nuts, and similar devices shall be chosen from the recommended selection contained in paragraph titled Recommended Selection of MIL-S-7742, unless used for adjustment, when they may be of fine or extra fine thread series.

b. When MIL, AN, or other specifications for components such as variable resistors and switches are in conflict with the requirements of 14.1.1a, the requirements of the specification for the component shall apply.

c. For high strength applications, MIL-S-8879 shall be used.

14.2 Thread sizes. The following thread sizes shall be utilized to the maximum extent possible:

.112-40 UNC	.2500-28 UNF	.5000-20 UNF
.138-32 UNC	.3125-24 UNF	.5625-18 UNF
.164-32 UNC	.3750-24 UNF	.6250-18 UNF
.190-32 UNF	.4375-20 UNF	

14.3 Screws and bolts. Screws and bolts shall conform to the specifications listed below unless design requirements dictate otherwise:

a. Machine screws shall conform to FF-S-92.

b. Cap screws shall conform to FF-S-85 or FF-S-86.

c. Setscrews shall conform to FF-S-200 or FF-S-210.

d. Self-locking screws shall conform to MIL-F-18240. Fiber inserts shall not be used as the locking device.

e. Tapping screws shall conform to FF-S-107.

f. Bolts shall conform to FF-B-575, MIL-S-1222, MIL-B-6812, MIL-B-7838, MIL-B-8831, or NAS498.

14.4 Nuts. Nuts shall conform to FF-N-836 or MIL-S-1222 and shall be preferably of the hexagon style with the following exceptions:

a. Nuts used in conjunction with a mechanical means to prevent rotation, press-type nuts, i.e., gang channel nuts, floating and self-aligning plate nuts, clinch-type or press-in nuts

b. Plate nuts of the lug style which are generally riveted or spot-welded to sheet structure

c. Nuts designed for a specific purpose, e.g., nuts for honeycomb structure

d. Sheet spring nuts shall not be used without specific approval of the procuring activity.

14.4.1 Self-locking nuts. Self-locking nuts shall conform to MIL-N-25027. Self-locking nuts shall not use fiber inserts as the locking device.

14.5 Lockwashers. Lockwashers shall conform to FF-W-84 or FF-W-100. Preassembled nut and lockwasher or screw and lockwasher assemblies are considered satisfactory for use, provided they are replaceable by conventional nuts, screws, and lockwashers.

14.6 Inserts. Inserts shall be so constructed that they will not loosen when tightening or loosening the screw or stud. External threaded inserts shall be capable of being replaced with inserts which have identical internal threads.

14.7 Flat washers. Flat washers shall conform to FF-W-92 where applicable.

15. Materials and finishes. All bolts, screws, nuts, and other fastener hardware shall be fabricated of corrosion-resistant metals that will resist the corrosive effects of the specified service environment or shall be cadmium plated in accordance with appropriate class, type II of QQ-P-416, except that fasteners shall not be subject to embrittlement relief test. Tin plating in accordance with MIL-T-10727 may be used in lieu of cadmium plating if soldering to the part is required. Standard MS or AN parts with other suitable finishes will not require refinishing.

15.1 For dry-film lubricated nuts, the type and class of plating are optional if the nuts conform to the salt spray requirements for type II plating in accordance with QQ-P-416.

15.2 Other materials may be used where uniquely required by the design of the equipment. Materials shall not be used which take a permanent set under normal conditions of stress.

15.3 Thread locking and retaining compounds. Thread locking and retaining compounds shall conform to MIL-S-22473 or MIL-S-46163 and shall be applied in such a manner that the required level of locking or retaining is achieved and maintained. Such compounds shall:

a. Not be used where required electrical conductivity is impaired

b. Not be used where failure of the compound would endanger personnel or damage the equipment

c. Be compatible with the material and finish to which they are bonded and shall have no detrimental effect on the material or finish

d. Not cause or accelerate corrosion.

15.4 Safety wiring and cotter pins. Application of safety wiring and cotter pins shall conform to MS33540, where practicable. Safety wiring and cotter pins shall not be used on terminals such as screws and threaded studs required to function as electrical terminals.

15.5 Antiseize compounds. Antiseize compounds shall conform to MIL-T-22361 or TT-S-1732. Graphite base antiseize compounds shall not be used.

REQUIREMENT 13

STRUCTURAL WELDING

1. Purpose. This requirement establishes criteria for structural welds. Welded electrical connections are excluded from this requirement.

2. Documents applicable to Requirement 13:

MIL-W-6858	Welding, Resistance; Aluminum, Magnesium, Nonhardening Steels or Alloys, Nickel Alloys, Heat-Resisting Alloys, and Titanium Alloys, Spot and Seam
MIL-W-8604	Welding of Aluminum Alloys; Process for
MIL-W-8611	Welding, Metal Arc and Gas, Steels, and Corrosion and Heat Resistant Alloys, Process for
MIL-W-18326	Welding of Magnesium Alloys, Gas and Arc, Manual and Machine Processes for
MIL-W-46132	Welding, Fusion, Electron Beam, Process for
MIL-STD-22	Welded-Joint Designs
MIL-STD-248	Welding and Brazing Procedure and Performance Qualification
MIL-STD-1261	Welding Procedures for Constructional Steels
MIL-STD-1595	Aerospace Welder Performance Qualification (Supplement to ASME Boiler and Pressure Vessel Code, Section IX, 1974)
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
ANSI Y32.3-1969	Welding Symbols
AWS A3.0-80	Welding Terms and Definitions

3. General. The joint areas of all parts to be welded shall be cleaned of contaminants and materials which may be detrimental to obtaining satisfactory welds. The fusion, penetration, and size of the weld shall be sufficient to meet the design requirements. Degradation of material properties in the heat affected zone caused by welding shall be considered. Weldments shall be stress relieved when induced stress resulting from welding, design configuration, or materials welded may be harmful. (See ANSI Y32.3-1969 for welding symbols, AWS A3.0-80 for welding terms and definitions, and MIL-STD-22 for welded joint designs.)

4. Arc and gas welding. Unless otherwise specified in the detail equipment specification, welding by arc and gas methods shall be performed by operators who have passed the applicable certification tests and have a certificate of proficiency in accordance with MIL-STD-248 or MIL-STD-1595. Electrodes used in arc welding shall be of the type that will produce a weld having chemical and physical properties similar to those of the parent metal. For the materials indicated, welding shall conform to the following specifications:

a. Welding of aluminum alloys: MIL-W-8604

b. Welding of magnesium alloys: MIL-W-18326

c. Welding of steel alloys: MIL-W-8611.

5. Resistance welding. Where structural spot welding is used, the number of welds shall be sufficient to provide adequate strength for the intended purpose

with no less than two welds on each part. Spot welding of joints shall conform to the process requirements of MIL-W-6858. MIL-HDBK-5 may be used as a guide for spot-to-sheet edge distances and allowable strengths.

6. Noncritical applications. In ground equipment applications, welding procedures in accordance with MIL-STD-1261 may be used where, if the weld should fail, it will not compromise personnel or equipment safety or prevent completion of the mission.

7. Other methods. Other welding methods, such as the electron beam process (MIL-W-46132), may be used provided approval is obtained from the procuring activity.

REQUIREMENT 14

TRANSFORMERS, INDUCTORS, AND COILS

1. Purpose. This requirement establishes the requirements for transformers, inductors, and coils.

2. Documents applicable to Requirement 14:

MIL-T-27	Transformers and Inductors (Audio, Power, and High Power Pulse), General Specification for
MIL-C-15305	Coils, Fixed and Variable, Radio Frequency, General Specification for
MIL-T-21038	Transformers, Pulse, Low Power, General Specification for
MIL-C-39010	Coils, Fixed, Radio-Frequency, Molded, Established Reliability, General Specification for
MIL-T-55631	Transformers, Intermediate Frequency, Radio Frequency and Discriminator, General Specification for
MIL-T-83721	Transformer, Variable, Power, General Specification for
MIL-STD-1286	Transformers, Inductors, and Coils, Selection and Use of

3. Selection. Selection of transformers, inductors, and coils shall be in accordance with MIL-STD-1286 and the following paragraphs.

4. Audio, power, and high-power pulse transformers and inductors. Audio, power, and high-power pulse transformes and inductors shall conform to MIL-T-27 with grade, class, and life expectancy as listed in table 14-I.

Table 14-I. Audio, power, and high power pulse transformers

Application	Grade 1/	Temperature class
Shipboard, transportable and ground-mobile	4 or 5	R, S, V, or T
Ground-fixed	4 or 5	Q, R, S, or V
Aircraft and missile	4 or 5	R, S, T, or U

1/ Grade 6 transformers and inductors may be used in hermetically sealed or encapsulated assemblies only.

5. Intermediate, radio frequency and discriminator transformers. Intermediate, radio frequency and discriminator transformers shall conform to grade 1, 2, or 4 of MIL-T-55631. The use of grade 3 tranformers shall be limited to hermetically sealed or encapsulated assemblies.

6. Radio frequency coils. Radio frequency coils shall conform to grade 1, class O, A, B, or C of MIL-C-15305, except that radio frequency coils, fixed, molded, with established failure rate levels shall conform to MIL-C-39010.

7. Low-power pulse transformers. Low-power pulse transformers shall conform to MIL-T-21038 with grade, class, and life expectancy as specified in table 14-II.

Table 14-II. Low-power pulse transformers

Application	Grade	Temperature class	Life expectancy
Shipboard, transportable and ground-mobile	4 or 5	R, S, T, or U	X
Ground-fixed	4 or 5	Q, R, S, or T	X
Aircraft and missile	4, 5, 6 or 7	R, S, U, or V	X

8. General. Transformers and inductors, whether selected from the above or especially designed with procuring activity approval for a particular application, shall conform to the following:

a. Size and weight. The size and weight of tranformers and inductors shall be held to a minimum consistent with required performance and life. Every effort shall be made to use materials of light weight and to employ methods of design and construction which assure minimum size and weight. High temperature rise is permitted when size and weight savings can be effected, provided dependability, performance, efficiency, and required life are obtained. The best available grades of core materials shall be used to the maximum extent justifiable for the particular application.

b. Variable inductors. When a roller or slider is used in contact with the conductor of variable inductors, suitable provision shall be made to limit the travel of the roller or slider to prevent its leaving the conductor.

c. Variable transformers. Variable transformers shall conform to MIL-T-83721.

REQUIREMENT 15

FERROUS ALLOYS, CORROSION RESISTANCE

1. Purpose. This requirement establishes criteria for the selection and application of ferrous alloys and the corrosion resistant properties and treatments thereof.

2. Documents applicable to Requirement 15:

QQ-I-666	Iron Castings, Malleable
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-S-624	Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose)
QQ-S-631	Steel, Bar, Carbon, Hot Rolled (Special Quality)
QQ-S-698	Steel, Sheet and Strip, Low-Carbon
QQ-S-700	Steel, Sheet and Strip, Medium and High Carbon
QQ-S-763	Steel Bars, Shapes, and Forgings, Corrosion-Resisting
9Q-S-766	Steel Plates, Sheets, and Strip, Corrosion Resisting
QQ-S-777	Steel, Carbon, Strip, Cold-Rolled, Untempered Spring Quality
QQ-T-830	Tube, Steel (Carbon, Mechanical; Seamless and Welded)
QQ-W-423	Wire, Steel, Corrosion-Resisting
QQ-W-470	Wire, Steel, Carbon, Spring, Music
QQ-Z-325	Zinc Coating, Electrodeposited, Requirements for
MIL-S-867	Steel Castings, Corrosion Resisting Austenitic
MIL-S-4043	Steel, Corrosion-Resisting (Extra Low Carbon Type 304) Plate, Sheet, and Strip
MIL-S-5002	Surface Treatments and Metallic Coatings for Metal Surfaces of Weapons Systems
MIL-T-8506	Tubing, Steel, Corrosion-Resistant, (304), Annealed, Seamless and Welded
MIL-T-8606	Tubing, Steel, Corrosion-Resistant (18-8 Stabilized)
FED-STD-151	Metal, Test Methods

3. Definitions. The following definition applies to Requirement 15.

3.1 Destructive corrosion. Destructive corrosion shall be construed as being any type of corrosion that in any way interferes with mechanical or electrical performance.

4. Corrosion resistance. Ferrous alloys shall be corrosion-resisting types or shall be suitably protected to be capable of withstanding a salt spray test for a minimum of 48 hours in accordance with FED-STD-151. Where cleaning operations on metal parts are not specified in detail, they shall be in accordance with the best commercial practices which will not cause subsequent destructive corrosion.

5. Selection. The use of corrosion-resisting ferrous alloys is preferred to the use of plated and organically finished ferrous alloys if the application justifies their use.

5.1 Iron and steel. The use of iron or steel, except where specifically required for electromagnetic or low-frequency shielding purposes, shall be kept

to a minimum commensurate with strength requirements. Where closures, cases, frames, panels, brackets, and miscellaneous hardware are fabricated of steel, such material shall be treated to prevent corrosion. Cast iron shall not be used, except as indicated in the general equipment specification. Iron and steel, when used, shall conform to the following typical but not exclusive specifications, as applicable:

Specification	Subject
QQ-I-666	Iron Castings, Malleable
QQ-S-624	Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose)
QQ-S-631	Steel, Bar, Carbon, Hot Rolled (Special Quality)
QQ-S-698	Steel, Sheet and Strip, Low-Carbon
or	
QQ-S-700	Steel, Sheet and Strip, Medium and High Carbon
or	
QQ-S-777	Steel, Carbon, Strip, Cold-Rolled, Untempered Spring Quality
QQ-T-830	Tube, Steel, (Carbon, Mechanical; Seamless and Welded)
QQ-W-470	Wire, Steel, Carbon, Spring, Music

5.2 Corrosion-resisting ferrous alloys. Corrosion-resisting steel shall be used for all structural parts which will be subjected to severe corrosive conditions, such as exposure to sea water and combustion gases. They shall be the austenitic corrosion-resisting steels, such as 302, 303, 304, 304L, 309, 310, 316, 316L, 321, 322, 322A, and 347 and shall conform to the following typical but not exclusive specifications, as applicable:

Specification	Subject
QQ-S-763	Steel Bars, Shapes, and Forgings, Corrosion-Resisting
QQ-S-766	Steel Plates, Sheets, and Strip, Corrosion-Resisting
QQ-W-423	Wire, Steel, Corrosion-Resisting
MIL-S-867	Steel Castings, Corrosion Resisting Austenitic
MIL-S-4043	Steel, Corrosion-Resisting (Extra Low Carbon Type 304), Plate, Sheet, and Strip
MIL-T-8506	Tubing, Steel, Corrosion-Resisting, (304), Annealed, Seamless and Welded
MIL-T-8606	Tubing, Steel, Corrosion-Resistant (18-8 Stabilized)

6. Corrosion protection

6.1 Corrosion-resisting steels. Corrosion-resisting steels shall be given a passivation treatment but need not receive any other protection plating or finish, unless such plating or finish is necessary or desirable for electrical or mechanical reasons. Passivation shall be performed after all fabricating operations, such as welding and machining, have been completed.

6.2 Iron and steel. Ordinary iron and steel shall be plated or finished to resist corrosion, except for the following conditions:

a. Iron or steel lamination used in magnetic circuits need not be plated or given a protective finish if they are otherwise protected against corrosion.

b. Ferrous metal mechanisms that are bathed in oil or packed in grease, such as bearings, gears, and cams, or potted or hermetically sealed items, shall not receive protective coatings.

6.2.1 Corrosion-resisting treatments. Corrosion-resisting treatments shall be applied after all fabricating operations, such as welding and machining, have been completed. The corrosion-resisting treatments and metallic coatings shall be in accordance with the applicable portions of MIL-S-5002 and the following:

a. Cadmium-plated parts. Cadmium plating shall be in accordance with type II, class 1 of QQ-P-416 plating with the following exceptions:

(1) Bolts, studs, washers, nuts, and articles with portions externally threaded. These parts have a minimum of class 3 thickness.

(2) Parts whose dimensional tolerances will not permit a class 2 thickness shall be given the maximum thickness of plating compatible with dimensional tolerances.

(3) Holes, recesses, internal threads, and other areas where a controlled deposit cannot be obtained normally shall not be subject to a thickness requirement.

(4) Corrosion-resistant internal-threaded inserts, or protective antiseize compounds, or internal threads, shall be used where necessary in cadmium-plated parts.

b. Zinc and zinc-plated parts. Zinc and zinc-plated parts shall be given a dichromate treatment in accordance with QQ-Z-325.

REQUIREMENT 16

DISSIMILAR METALS

1. Purpose. This requirement establishes criteria for the selection and protection of dissimilar metal combinations and other significant corrosion behavior factors.

2. Document applicable to Requirement 16:

MIL-STD-889 Dissimilar Metals

3. Selection and application. Selection of metals for use in electronic equipment shall be made in accordance with the requirements of MIL-STD-889. Where electronic design requirements preclude the insulation of incompatible metal combinations as identified in MIL-STD-889 from one another, specific attention should be paid to isolating the combination from exterior environments.

REQUIREMENT 17

PRINTED WIRING

1. Purpose. This requirement establishes criteria for the design and treatment of printed wiring boards and assemblies.

2. Documents applicable to Requirement 17:

MIL-P-13949	Plastic Sheet, Laminated, Copper Clad (For Printed Wiring)
MIL-P-28809	Printed Wiring Assemblies
MIL-I-46058	Insulating Compound, Electrical (For Coating Printed Circuit Assemblies)
MIL-P-46843	Printed Wiring Assemblies
MIL-P-50884	Printed Wiring, Flexible, General Specification for
MIL-P-55110	Printed Wiring Boards
MIL-F-55561	Foil, Copper, Cladding for Printed Wiring Boards
MIL-STD-275	Printed Wiring for Electronic Equipment

3. Rigid printed wiring and printed wiring boards. Rigid printed wiring and printed wiring boards for single-sided, double-sided, and multilayer printed wiring shall conform to MIL-STD-275 and MIL-P-55110. The materials used for single-sided and double-sided printed wiring shall conform to MIL-P-13949. The materials used for multilayer printed wiring shall conform to MIL-P-13949 and MIL-F-55561.

3.1 Printed wiring board size. Whenever cost and technical requirements permit, preferred rigid printed wiring board sizes should be used. These board sizes will facilitate the development and use of standardized insertion end extraction tools. The preferred board sizes and extractor hole size and location are shown in figure 17-1.

3.2 Rigid printed wiring assemblies. Rigid printed wiring assemblies consisting of rigid printed wiring boards on which separately manufactured parts have been added shall conform to MIL-P-28809. For Army missile weapon systems, MIL-P-46843 shall apply.

3.3 Conformal coating. When conformal coating is required, rigid printed wiring assemblies shall be conformally coated with a coating material which conforms to MIL-I-46058.

4. Flexible printed wiring. Flexible printed wiring shall conform to MIL-P-50884.

BOARD NO.	PRINTED WIRING BOARD SIZE IN NOMINAL ±.015
A 1	2.0 X 3.0
A 2	2.0 X 4.5
A 3	2.0 X 6.5
A 4	2.0 X 8.0
B 1	5.0 X 3.0
B 2	5.0 X 4.5
B 3	5.0 X 6.5
B 4	5.0 X 8.0
C 1	6.5 X 3.0
C 2	6.5 X 4.5
C 3	6.5 X 6.5
C 4	6.5 X 8.0
D 1	8.0 X 3.0
D 2	8.0 X 4.5
D 4	8.0 X 8.0

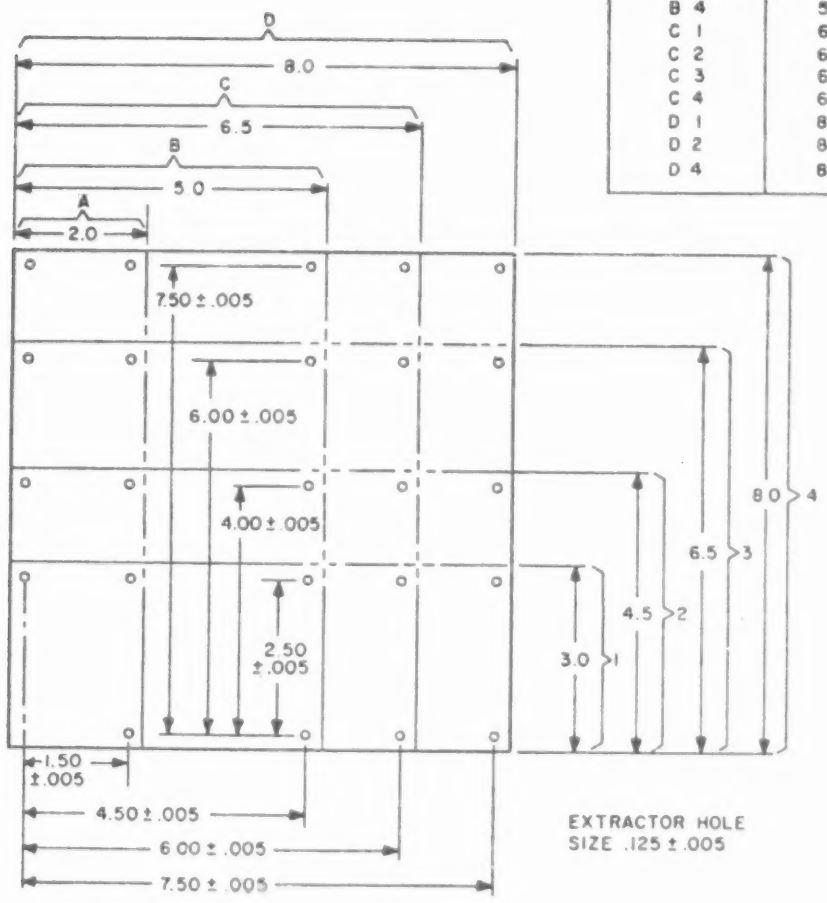


Figure 17-1. Preferred Printed Wiring Board Sizes

REQUIREMENT 18

DERATING OF ELECTRONIC PARTS AND MATERIALS

1. Purpose. This requirement establishes criteria for derating of electronic parts and materials.

2. Derating. In the application of electronic parts and materials, the parts and materials selected shall be used within their electrical ratings and environmental capabilities (e. g., any ambient or hot spot temperatures, voltage, current, or power dissipation). Derating shall be accomplished as necessary to assure the required equipment reliability within the specified operating conditions.

REQUIREMENT 19

TERMINATIONS

1. Purpose. This requirement establishes criteria for the selection and use of terminations.

2. Documents applicable to Requirement 19:

MIL-T-7928	Terminals, Lug and Splice, Crimp-Style, Copper
MIL-T-15659	Terminal, Lug, Solder Type, Copper
MIL-T-55156	Terminals, Lug, Splices, Conductor; Screw Type, General Specification for
MIL-T-55164	Terminal Boards, Molded, Barrier, Screw Type, and Associated Terminal Board Lugs, General Specification for
MIL-STD-1277	Splices, Clips, Terminals, Terminal Boards, Binding Posts, Electrical
MS 27212	Terminal Boards, Assembly, Molded-in Stud, Electric

3. Part terminations. The applicable part specifications shall control the part termination. Termination of parts for which there is no applicable part specification shall be mechanically strong. Terminals of potted parts shall be fastened to a terminal insulating strip or plate (or the enclosure itself, if this complies with the insulation requirements) in such manner as to prevent loosening or degradation in the moisture-excluding property of the enclosure by normal connecting and disconnecting of external leads. Terminals shall be so spaced as to prevent corona discharge, breakdown, and low leakage resistance under specified conditions of high humidity (including condensation) and high altitude for the particular application.

4. Terminals

4.1 Number of wires per terminal or lug. The number of wires terminated in an individual terminal or lug shall not be greater than three. Multisection turret, bifurcated, or multi-hole lug terminals shall have not more than three wires per section, tong, or hole. In no case shall the total circular mil area of the terminated wires exceed the circular mil area capacity of the terminal or lug. If a greater number of wires is required than those specified herein, approval of the procuring activity shall be obtained.

4.2 Lug terminals. Lug terminals shall conform to one of the following specifications, and wherever possible shall be selected from MIL-STD-1277:

MIL-T-7928	Crimp, insulated and noninsulated
MIL-T-15659	Solder
MIL-T-55156	Screw

4.2.1 Crimping of terminal lugs. Crimping of terminal lugs shall be so accomplished that the connections will meet the resistance (voltage drop) and tensile strength requirements and tests of MIL-T-7928.

4.2.2 Crimping tools. Crimping tools shall be as specified in the individual terminal specification. However, contractors may use tooling as recommended by the terminal or tooling manufacturer provided that the finished crimp meets all

of the performance requirements of the terminal specification. Maintenance instructions and other data supplied by the contractor shall list the military standard tools, terminals and splices.

5. Terminal boards and terminal junction systems

5.1 Terminal boards. Terminal boards shall be selected from MIL-STD-1277. Other subassemblies commonly known as terminal boards are not covered by this Requirement.

5.1.1 Mounting. Terminal boards shall be secured only by bolts (machine screws) and shall be capable of ready removal and replacement. They shall be mounted in the position that will best facilitate the testing of the equipment.

5.1.2 Number of lugs per terminal. The maximum number of lugs to be connected to any one terminal on a terminal board shall be two for screw-type terminal boards covered by MIL-T-55164 and as specified in the detail specification sheets for stud-type terminal boards. Not more than four lugs shall be connected to any one terminal of a board covered by MS27212. Accessories such as stud connectors, straddle plates, jumpers and terminal board lugs shall be counted as lugs for this purpose.

5.2 Terminal junction systems. Terminal junction systems shall be selected from MIL-STD-1277.

6. Stud terminals, feed-through terminals, and binding posts

6.1 Selection. Stud terminals, feed-through terminals and binding posts shall be selected from MIL-STD-1277.

6.2 Mounting. Adequate spacing or barriers shall be employed between adjacent stud or feed-through terminals or binding posts to prevent corona discharge, breakdown, and low-leakage resistance under specified environmental conditions such as high humidity (including condensation) and high altitude for the particular application. Terminals shall not turn or loosen or deteriorate when the equipment is subjected to specified service conditions, such as shock and vibration. Terminals mounted on boards shall not cause cracking or delamination of the board.

REQUIREMENT 20

WIRE, HOOKUP, INTERNAL

1. Purpose. This requirement establishes criteria for the selection and application of electrical internal hookup wire.

2. Documents applicable to Requirement 20:

QQ-W-343	Wire, Electrical (Uninsulated)
MIL-W-76	Wire and Cable, Hookup,Electrical,Insulated
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-W-16878	Wire, Electrical, Insulated, High Temperature
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy
MIL-W-81822	Wire, Electrical, Solderless Wrap, Insulated and Uninsulated
MIL-STD-681	Identification Coding and Application of Hook-up and Lead Wire

3. General requirements

3.1 Wire. Internal hookup wire shall be selected from the types and classes specified by the documents listed herein whenever applicable. Other types of wire may be used provided they are selected from specifications acceptable for the specific application and approved by the procuring activity.

3.1.1 Identification. Hookup wires in the equipment shall be, insofar as practicable, distinctly coded in color or numbered. Codes, when used, shall be in accordance with MIL-STD-681 or as otherwise agreed upon with the procuring activity. Numbers shall not be used where they would be difficult to read or trace, such as in compact assemblies.

3.2 Wire characteristics

3.2.1 Solid or stranded. Stranded wire shall be used for conductors and cables which are normally flexed in use and servicing of the equipment, such as cables attached to the movable half of detachable connectors and hanging cables attached to removable or movable doors and shields. Leads six inches or less in length may be run as solid wires unless they form interconnections between

Table 20-I. Wire, Electrical

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	1/ Conductor Coating	1/ Conductor Type	2/ Insulation Primary	2/ Insulation Primary Cover	2/ Insulation Jacket	Max Cond Temp oC	Max rms Volts	Remarks
MIL-W-76	Wire and Cable, Hook-up, Electrical, Insulated	LW	Cu/A or CCW	Sn	S or Str	1	8,10,13A3/	8,10,13A3/	80	300	(a) See Note 4
		MW								1000	(b) For US Army use only
		HW	Cu/A or CCW	Sn	S or Str	1	8,10,13A3/	8,10,13A3/	80	2500	
		HF				2A				1000	
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy	/1	Cu/A	Sn	Str	1		5	105	600	
		/2						8, 11		1000	
		/4						8		3000	
		/5	Cu/A	Sn				9A	110	600	
		/6	HSA	Ag							
		/7	Cw/A	Sn	Str	1		8	105		
MIL-W-16878	Wire, Electrical, Insulated, High Temperature	/1-P	Cu/A	Sn	Str	1	8,10,11	1,8,10,11	105	600	(a) High strength copper alloy conductor allowed in AWG sizes 26 through 32
		/2-C								1000	
		/3-D								3000	
		/4-E		Ag		3A,3B		3A,3B,13B3/4A	200	600	
				Ni					260		
		/5-EE		Ag					200	1000	
				Ni					260		(b) See Note 4
		/6-ET		Ag					200	250	
				Ni		3A,3B		3A,3B,13B3/4A	260		
		/7-F								600	
		/8-FF		Ag		6	4A,8,10,11	4A,8,10,11	200	1000	
		/9-FFW									
		/10-J		Sn		2A	8,10,11		75	600	
		/11-K									
		/12-KK		Ag		4A		4A	200	1000	
		/13-KT	Cu/A		Str					250	
MIL-W-19150	Wire, Insulated, Hard Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy	/9	Cu/A	Ag	Str	3A			200	1000	
		/10		Ni					260		
		/11		Ag					200	600	
		/12		Ni		3A			260		
		/14	Cw/A	Sn		4A		9B	135		
		/15	HSA	Ag							
		/16	Cu	Sn		17			150		
		/17	HSA	Ag							
		/18	Cu	Sn							
		/19	HSA	Ag		17			150	600	
		/21		Ni		3A			260	1000	
		/22		Ag					200	600	
		/23	HSA	Ni		3A			260		
		/31	HSA	Ni		3A		7	260		
		/32	Cw/A	Sn		21			150		
		/33	HSA	Ag							
		/34	Cw/A	Sn				21			
		/35	HSA	Ag		21			150		
		/36	Cw/A	Sn		28		18	135		
		/37	Cw/A	Sn							
		/38	HSA	Ag							
		/39	Cw/A	Sn							
		/40	HSA	Ag		28		18	135		
		/41	Cw/A	Ni		21		21	200		
		/42	HSA	Ni	Str					600	

Table 20-I (Continued)

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Coating	Type	2/ Insulation Primary	Primary Cover	Jacket	Max Cond Temp °C	Max rms Volts	Remarks
MIL-W-81044	Wire, Electric, Cross-Linked Polyalkene etc Insulated	/4	Cu/A	Sn	Str	2B		9B	135	600	See application temp limitation on detail spec sheet
		/12			↕				150	↕	
		/13	HSA	Ag	Str					600	
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	/7	Cu/A	Ag	Str	19		4B	200	600	
		/8		Ni	↕	↕		↕	↕	↕	
		/9	HSA	Ag	↕	↕	4B	4B	200	↕	
		/10		Ni	↕	↕				↕	
		/17	Cu	Ag	↕	↕		20	↕	↕	
		/18		Ni	↕	↕		↕	↕	↕	
		/19	HSA	Ag	↕	↕		↕	↕	↕	
		/20		Ni	↕	↕		↕	↕	↕	
		/21	Cu/A	Sn	↕	↕		↕	150	↕	/11 and /12 have a bright aromatic polyamide braid with clear finisher coatings on 8 AWG and larger
		/22	Cu/A	Sn	↕	↕		↕	↕	↕	
		/11	Cu/A	Ag	↕	↕		↕	200	↕	
		/12	Cu/A	Ni	↕	↕		↕	↕	↕	
		/13	HSA	Ag	↕	↕		↕	↕	↕	
		/14	HSA	Ni	Str	19		20	200	600	

NOTES:

1/

Conductor Code		Description
Material	Cu/A	Copper, annealed
	Cu/H	Copper, hard drawn
	CCW	Cooper covered steel
	HSA	High strength copper alloy
	Al	Aluminum
Coating	Sn	Tin
	Ag	Silver
	Ni	Nickel
Type	S	Solid
	Str	Stranded

3/ When specified on purchase order

4/ Various combinations of primary, primary cover, and jacket insulations and unshielded, shielded, etc, constructions are available to meet application requirements. See detail wire specification.

2/

Insulation Code	Description
1	Polyvinyl chloride/extruded
2A	Polyethylene/extruded
2B	Polyalkene/cross-linked/extruded
3A	Polytetrafluoroethylene/extruded (TFE teflon)
3B	Polytetrafluoroethylene/tape
3C	Polytetrafluoroethylene/mineral filled/extruded
4A	Fluorinated ethylene propylene/extruded (FEP teflon)
4B	Fluorinated ethylene propylene/dispersion
6	Silicone rubber/extruded
7	Polyimide lacquer (Pure ML)
8	Polyamide/extruded (Nylon)
9A	Polyvinylidene fluoride/extruded (Kynar)
9B	Polyvinylidene fluoride/extruded/cross-linked
10	Braid/synthetic yarn/lacquer impregnated
11	Braid/nylon/impregnated
13A	Braid/glass fiber/impregnated
13B	Braid/TFE coated glass fiber/TFE finish
17	ETFE fluoropolymer
18	Fluoropolymer cross-linked ECTFE
19	Fluorocarbon/polyimide tape
20	Modified aromatic polyimide resin
21	Cross-linked, extruded, modified ethylene-tetrafluoroethylene

shock isolation mounted parts and nonshock isolation mounted parts. There are some other instances, such as wire wrapping, where a solid conductor may be required regardless of length.

3.2.2 Size. Conductors shall be of such cross section, temper, and flexibility as to provide ample and safe current-carrying capacity and strength. In general, wire shall not be smaller than size 22. Smaller wire may be used when benefits can be obtained with no loss in performance. Specifically, smaller wire may be used in cables having larger numbers of wires and adequate support against vibration. Smaller size wire may be used when necessary for welding of electronic interconnections.

3.2.3 Bare wire. Bare hookup wire shall not be used unless insulated wire is impractical because of circuit characteristics or shortness of wire run. Bare hookup wire shall be type S, soft or drawn and annealed, and coated, and shall conform to QQ-W-343.

3.2.4 Thermocouple wire. Selection of thermocouple wire shall be in accordance with MIL-W-5845, MIL-W-5846, or MIL-W-5908.

4. Detail requirements

4.1 Selection of wire. Selection of internal hookup wire shall be in accordance with table 20-I unless otherwise specified in the detail equipment specification. For solderless wrap applications, wires shall be selected which are in accordance with MIL-W-81822. Certain insulating materials exhibit a cold flow characteristic. Caution should be used in the selection of these materials in applications requiring restrictive clamping or tying, etc., where this feature may result in exposed or shorted conductors.

4.2 Application restrictions

4.2.1 MIL-W-76 shall be used for Army applications only.

4.2.2 MIL-W-16878 shall not be used for Air Force space applications.

4.2.3 MIL-W-22759 shall not be used in Air Force space applications except for MIL-W-22759/32, /33, /34, /35, /41, and /42.

4.2.4 Wires with polyvinyl chloride insulation shall not be used in manned aerospace applications.

REQUIREMENT 21

CASTINGS

1. Purpose. This requirement establishes criteria for the design, classification, inspection, and repair of castings.

2. Documents applicable to Requirement 21:

MIL-C-6021	Castings, Classification and Inspection of
MIL-STD-276	Impregnation of Porous Nonferrous Metal Castings

3. Application and selection. In any design utilizing metallic castings, consideration shall be given to intended application, the availability of molding and casting alloys, the choice of a suitable casting process (see table 21-I), and the use of ribs and fins.

Table 21-I. General Comparison of Metallic Casting Processes

Type of castings	Dimensional accuracy	Ability to reproduce fine detail	Tool cost	Suitability for volume production	Surface smoothness	Suitability for large sized castings
Sand	3	3	1	3	3	1
Die	1	1	3	1	1	3
Investment	1	1	3	2	1	3
Shell mold	2	2	3	1	2	3
Permanent mold	2	2	3	1	2	2
Plaster mold	2	1	1	3	2	3

Legend: 1 = Very good; 2 = good; 3 = fair

4. Die castings. Die castings shall not be used where the casting might be subject to impact. Zinc alloy die castings shall not be used where dimensional changes of the casting could affect use of equipment.

5. Inserts. Inserts which are intended to be cast in place shall be knurled, grooved, or otherwise prepared to secure satisfactory keying of the insert to the casting. Inserts shall be fabricated from a material which is not adversely affected by exposure to the molten casting alloy. When inserts are located near a casting edge, sufficient edge distance shall be allowed in order to develop the required resistance to insert pull-out, and to avoid cracking of the casting. Casting defects resulting from use of inserts, such as partial alloying, poor bonds, porosity, and cracks shall not be present.

6. Porous castings. When required, castings shall be impregnated in accordance with MIL-STD-276.

7. Repair. Repair of minor surface defects in castings by welding will be permitted only when specific approval has been granted by the procuring activity. In all cases, permission to weld and procedures to be used shall be approved by the procuring activity. Unless otherwise approved by the procuring activity, welding shall be limited to a maximum of 10 percent of cross-sectional

area and to areas where no severe stress or fatigue will be encountered. With heat-treatable alloys, repair welding shall be followed by a complete heat-treating cycle.

8. Classification and inspection. Castings shall be classified and inspected in accordance with MIL-C-6021.

REQUIREMENT 22

PARTS SELECTION AND CONTROL

* 1. Purpose. This requirement offers direction as to parts selection and control which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Parts selection and control must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Document applicable to requirement 22:

MIL-STD-965	Parts Control Program

* 3. Parts control program. MIL-STD-965 establishes two procedures covering the submission, review, and approval of Program Parts Selection Lists and changes thereto. The objective is to achieve life cycle cost savings and cost avoidances by: (1) assisting equipment or system managers and their contractors in the selection of parts commensurate with contractual requirements, (2) minimizing the variety of parts used in new design, (3) enhancing interchangeability, reliability, and maintainability of military equipments and supplies, and (4) conserving resources. MIL-STD-965 must be tailored when applied; application guidance is offered in the document.

REQUIREMENT 23

ADHESIVES

1. Purpose. This requirement establishes criteria for the selection and application of adhesives.

2. Documents applicable to Requirement 23:

MMM-A-121	Adhesive, Bonding, Vulcanized Synthetic Rubber to Steel
MMM-A-130	Adhesive, Contact
MMM-A-131	Adhesive, Glass-to-Metal (For Bonding of Optical Elements)
MMM-A-132	Adhesive, Heat Resistant, Airframe Structural, Metal to Metal
MMM-A-134	Adhesive, Epoxy Resin, Metal to Metal Structural Bonding
MMM-A-138	Adhesive, Metal to Wood, Structural
MMM-A-181	Adhesive, Phenol, Resorcinol, or Melamine Base
MMM-A-189	Adhesive, Synthetic-Rubber, Thermoplastic, General Purpose
MMM-A-1617	Adhesive, Rubber Base, General Purpose
MIL-A-3920	Adhesive, Optical, Thermosetting
MIL-A-5540	Adhesive, Polychloroprene
MIL-A-8576	Adhesive, Acrylic Base, for Acrylic Plastic
MIL-A-22010	Adhesives, Solvent Type, Polyvinylchloride
MIL-A-22397	Adhesive, Phenol and Resorcinol Resin Base (for Marine Service Use)
MIL-A-22895	Adhesive, Metal Identification Plate
MIL-A-24179	Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-A-25463	Adhesive, Metallic Structural Sandwich Construction
MIL-A-46050	Adhesive, Cyanoacrylate, Rapid Room-Temperature Curing, Solventless
MIL-A-46146	Adhesive-Sealants, Silicone, RTV, Non-Corrosive (For Use with Sensitive Metals and Equipment)
MIL-A-52194	Adhesive, Epoxy (For Bonding Glass Reinforced Polyester)
MIL-A-81236	Adhesive, Epoxy Resin With Polyamide Curing Agent
MIL-A-81253	Adhesive, Modified Epoxy Resin With Polyamine Curing Agent
MIL-A-83377	Adhesive Bonding (Structural) For Aerospace and Other Systems, Requirements for
MIL-HDBK-691	Adhesives
ASTM Standard	Wood; Adhesives - Part 22

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.

3. Characteristics. Adhesives are substances capable of holding materials together by surface attachment. Depending on the adhesive method chosen, the designed strength can vary from easily separable to bonds exceeding the inherent strength of the substrate. Adhesive is a general term and includes, among others, cement, glue, mucilage and paste. All of these terms are loosely used interchangeably. Varied terminology is used to indicate adhesive characteristics (e. g., physical descriptions, such as liquid or tape adhesives; chemical descriptions, such as resin or silicate adhesives; descriptions indicating adherends, such as rubber, metal, plastic or fabric adhesives; descriptions indicating use, such as high and low temperature or pressure-sensitive adhesives).

4. Classification. The major types of adhesives are listed below.

4.1 Pressure-sensitive. Adhesives made to adhere to a surface by the brief application of pressure. Tapes, decals, and nameplates are often attached to surfaces using this type of adhesive. Advantages of this type are ease of application and ease of separation of the parts./ Disadvantages are lack of strength and poor solvent resistance.

4.2 Thermoplastic. Thermoplastic adhesives make up a large share of the adhesives in general use. They include those which set by solvent evaporation, solutions of natural products such as animal glues, processed natural products such as cellulosic household cements, and natural and synthetic rubber as in "contact" and general-purpose rubber adhesives. They also include solventless hot-melt adhesives, and thermoplastic adhesives which require addition of a chemical activator. All thermoplastic adhesives have a tendency to creep under load, especially at elevated temperature, and should not be used in critical structural applications. Many thermoplastic adhesives have limited or poor resistance to certain solvents.

4.3 Thermosetting. Thermosetting adhesives undergo a chemical reaction caused by catalysts, heat, and other methods leading to polymerization into a relatively infusible stage. This type is used in structural and nonstructural applications and can be modified for specific properties as needed. Many thermosetting adhesives cannot be used for structural applications and many cannot be used at elevated temperatures. However, thermosetting adhesives are generally more satisfactory for use at elevated temperatures than the conventional thermoplastic adhesives.

5. Considerations. The adhesive system shall be selected and used with due consideration for the following factors.

5.1 Design of joint. For structural functions, this is a matter of prime importance and good joint design practices shall be followed. The joint shall be designed to minimize concentrations of stress. The basic stress shall be in shear. The weakest design is where the basic stress is in cleavage or peel and non-axial loading in tension produces cleavage.

5.2 Magnitude, direction, and types of separation forces. The bonded joint shall resist fracture or separation resulting from stresses due to static loads, bending, mechanical shock, vibration, or thermal shock. This requires careful evaluation of the design and environmental requirements that will be met by the joint.

5.3 Materials to be bonded. The materials to be bonded assume critical importance as there are some materials, such as fluorocarbon, polyethylene, and nylon that cannot be bonded satisfactorily without prior treatment, special adhesives, or both. Therefore, a sound knowledge of materials and adhesive methods is necessary.

5.4 Production capability. It is important to adequately prepare the surface of the substrate, to apply the adhesive, and to set or cure it in accordance with the manufacturer's specifications or instructions. Adequate equipment is necessary for this purpose.

5.5 Deleterious effects. The user shall ascertain that the formulation of the adhesive selected shall have no deleterious effects on the bonded assembly or nearby items when the bonded assembly is in storage, transit, or use under the environmental conditions for which it was designed. Deleterious effects may be caused by the slow release of trapped solvents which can damage many types of rubber and plastic, or cause other harmful results degrading operation of the equipment.

5.6 Application. In general, the thicker the adhesive layer, the lower the shear resistance, but the higher the strength to impact and peeling. Care shall be taken to avoid starved joints which are the result of either absorption of adhesive by a porous material, poor application, inadequate coverage or excessive pressure. Where one or both of the adherends are porous, successive thin coats of adhesive shall be applied to completely seal the surface, and each coat shall be dry before the next coat is applied. This procedure shall be used instead of the application of one thick adhesive coat to the porous surface, except in the case of silicone adhesives.

5.7 Resistance to swelling. The adhesive shall be resistant to swelling or other deterioration caused by contact with air, moisture, fungus, gases, ozone, or solvents which will be encountered in use.

5.8 Structural compatibility. Adhesives which are not compatible structurally shall be avoided. For example, a brittle adhesive shall not be used for glass bonding because excessive shrinkage during setting or curing will load the glass in tension. For assemblies which may be flexed or subject to impact, a brittle adhesive shall not be used.

5.9 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

6. Guide for selection and application. The following, although not a complete list, may be used as a guide in selecting adhesives and bonding procedures to meet design requirements in electronic equipment:

MMM-A-121	MIL-A-3920	MIL-A-46050
MMM-A-130	MIL-A-5540	MIL-A-46146
MMM-A-131	MIL-A-8576	MIL-A-52194
MMM-A-132	MIL-A-22010	MIL-A-81236
MMM-A-134	MIL-A-22397	MIL-A-81253
MMM-A-138	MIL-A-22895	MIL-A-83377
MMM-A-181	MIL-A-24179	MIL-HDBK-691
MMM-A-189	MIL-A-25463	ASTM STD - Part 22
MMM-A-1617		

Many of these specifications have no requirements pertaining to electrical properties. Where electrical properties are important, the suitability of the material for the application shall be established.

REQUIREMENT 24

WELDS, RESISTANCE, ELECTRICAL INTERCONNECTIONS

1. Purpose. This requirement establishes criteria for resistance welds of electrical and electronic interconnections and part leads. This requirement does not include structural welds.

2. Document applicable to Requirement 24:

MIL-W-8939 Welding, Resistance, Electronic Circuit Modules

3. Welds and welding processes. Welds and welding processes shall be in accordance with MIL-W-8939.

3.1 Contaminants. All surfaces of leads or parts to be welded shall be free of contaminants which would adversely affect the forming of the welded joint.

3.2 Electrical connections. Except where needed to meet electromagnetic interference or system compatibility requirements, welded electrical connections shall not be used where it may be necessary to disconnect, replace, or reconnect a part or module during servicing.

3.3 Excess conductor wire. Excess conductor wire shall be trimmed sufficiently close to provide adequate clearance to prevent possible electrical shorting but not so close as to cause damage to the weld joint.

3.4 Strain relief. Each part lead terminating at a connection point shall have allowance for strain relief to minimize tensile or shear stress.

REQUIREMENT 25

ELECTRICAL POWER

1. Purpose. This requirement establishes criteria for electrical power.

2. Documents applicable to Requirement 25:

MIL-STD-205	Frequencies for Electric Power
MIL-STD-255	Electric Voltages, Alternating and Direct Current
MIL-STD-704	Aircraft Electric Power Characteristics
DOD-STD-1399	Interface Standard for Shipboard Systems
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements

3. Electrical power

3.1 General. Except as specified below, the electrical power source required for electronic equipment and associated equipment and for portions of systems employing electronic equipment shall be in accordance with MIL-STD-205 and MIL-STD-255. The characteristics and the utilization of power shall be in accordance with the individual equipment specification. The required characteristics shall be established, considering the type of power system characteristics provided for the application. Battery power source selection for Army is controlled by U.S. Army Materiel Development and Readiness Command regulation.

3.2 Airborne. The electrical power requirements for airborne and associated equipment shall be in accordance with MIL-STD-704.

3.3 Shipboard. The electrical power requirements for shipboard equipment shall be in accordance with Type I of section 300 of DOD-STD-1399.

3.4 Space. The electrical power requirements for space equipment shall be in accordance with MIL-STD-1539.

REQUIREMENT 26

ARC-RESISTANT MATERIALS

1. Purpose. This requirement establishes criteria for the selection and application of arc-resistant materials used for insulation of electrical power circuits.

2. Documents applicable to Requirement 26:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
ZZ-R-765	Rubber, Silicone
MIL-I-10	Insulating Materials, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-P-79	Plastic Rod and Tube, Thermosetting, Laminated
MIL-P-997	Plastic Material, Laminated, Thermosetting, Electrical Insulation, Sheets, Glass Cloth, Silicone Resin
MIL-P-15037	Plastic Sheet, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin
MIL-P-19161	Plastic Sheet, Laminated, Glass Cloth, Polytetrafluoroethylene Resin
MIL-M-24325	Molding Material, Plastic, Epoxy Compounds, Thermosetting
MIL-P-25518	Plastic Material, Silicone Resin, Glass Fiber Base, Low-Pressure Laminated
MIL-P-46112	Plastic Sheet and Strip, Polyimide
FED-STD-406	Plastics: Methods of Testing
ASTM D495-73	High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation, Test Method for

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Materials. Arc-resistant materials used for insulation of electrical power circuits, where arcing is likely to occur, shall conform to table 26-I. These materials shall be masked, if necessary, during any treatment of the equipment in which they are used which might result in degradation of the arc-resistant properties of the material. The materials listed herein have passed the minimum requirements of 115 seconds when subjected to the arc-resistance test of method 4011 of FED-STD-406 or ASTM D 495. Although satisfactory for illustrating the approximate arc-resistance ranking of insulating materials of different composition, for those parts which may be subjected to other than high voltage, low-current arcing, the materials should be evaluated for their overall thermal and electrical characteristics and for their suitability for the specific application. When evaluating arc-resistant materials, consideration should also be given to their electrical characteristics when subjected to the humidity conditions specified in the detail equipment specification.

4. Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

Table 26-I. Arc-Resistant Materials

Materials	Specification	Types
Ceramic	MIL-I-10	All
Plastic(s), thermo-setting, molding	MIL-M-14	CMI-5, GDI-30, GDI-30F, MAG, MAI-30, MAI-60, MAI-100, MAT-30, MDG, MME, MMI-5, MMI-30, MSG, MSI-30, SDG, SDG-F, SDI-30
Molding, epoxy compounds	MIL-M-24325	MEE
Laminated rods and tubes	MIL-P-79	GMG
Laminated sheets		
Glass cloth, melamine resin	MIL-P-15037	GME
Glass cloth, polytetra-fluoroethylene resin	MIL-P-19161	GTE
Glass cloth, silicone resin	MIL-P-997	GSG
Low pressure laminate, silicone resin, glass fiber base	MIL-P-25518	All
Sheet and rod, cast	L-P-516	E-2
Sheet and strip, polyimide	MIL-P-46112	All
Silicone rubber	ZZ-R-765	All

REQUIREMENT 27

BATTERIES

1. Purpose. This requirement establishes the criteria for the selection and application of batteries, including installation and marking criteria.

2. Documents applicable to Requirement 27:

W-B-134	Battery, Storage (Lead-Acid, Industrial Floating Service)
W-B-137	Battery, Storage (Nickel-Alkaline, Industrial Floating Service)
MIL-B-10154	Batteries, Primary, Water-activated (Dunk Type)
MIL-B-11188	Batteries, Storage, Lead-Acid
DOD-B-15072	Batteries, Storage, Lead-Acid, Portable, General Specification for (Metric)
MIL-B-49030	Batteries, Dry (Alkaline)
MIL-B-55118	Batteries, Storage, (Cells), Vented, Nickel-Cadmium
MIL-B-55130	Batteries, Storage, Sealed, Nickel-Cadmium
MIL-B-55252	Batteries, Magnesium, Dry
MIL-B-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft, General Specification for
MIL-B-83769	Batteries, Storage, Lead-Acid, General Specification for
MIL-STD-688	Batteries, Dry

3. Use. Batteries shall not be used unless approved by the procuring activity. (Battery power source selection for the Army is controlled by U.S. Army Material Development and Readiness Command regulation.)

4. Battery compartment. The battery compartment shall be provided with devices to firmly secure the batteries. Adequate room shall be provided for battery installation, maintenance, testing, and removal without disassembly of the equipment. The battery compartment shall prevent pressure buildup from heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture, and shall also prevent such materials from entering the electronic compartment.

4.1 Magnesium dry batteries. When magnesium dry batteries are used, extra precautions shall be observed since these batteries give off heat at high rates of discharge (less than 10 hours) and evolve hydrogen.

4.2 Lithium batteries. When lithium batteries are considered for use in an equipment, guidance on their use, transportation, storage, and disposal shall be requested through the procuring activity from the following sources:

For Army: US Army Electronics Technology and Devices Laboratory
ATTN: DELET-P
Ft Monmouth NJ 07703

For Navy: Naval Surface Weapons Center
ATTN: R33
Silver Spring MD 20910

Supersedes
REQUIREMENT 27
10 September 1979

REQUIREMENT 27
29 August 1980

For Air Force: Air Force Wright Aeronautical Laboratories
ATTN: POOC
Wright Patterson AFB OH 45433

5. Installation marking. Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required shall be marked as applicable in a prominent place on or adjacent to the battery compartment.

5.1 Warning label. Battery-powered equipment, with the exception of equipment requiring permanent battery installation, shall be labeled externally as follows:

WARNING
REMOVE BATTERIES BEFORE
SHIPMENT OR INACTIVE STORAGE
OF 30 DAYS OR MORE

Examples of equipment requiring permanent battery installation are sonobuoys, missiles, and fuzes.

6. Selection and application

6.1 Dry batteries. Dry batteries shall be selected and applied in accordance with MIL-STD-688, or shall conform to MIL-B-49030 or MIL-B-55252.

6.2 Other batteries. Other batteries shall conform to one of the following: W-B-134, W-B-137, MIL-B-10154, MIL-B-11188, DOD-B-15072, MIL-B-55118, MIL-B-55130, MIL-B-81757, or MIL-B-83769.

REQUIREMENT 28

CONTROLS

1. Purpose. This requirement establishes criteria for the selection and application of controls.

2. Documents applicable to Requirement 28:

MIL-K-3926	Knobs, Control (For Use with Electronic, Communications, and Allied Equipment)
MIL-K-25049	Knob, Control, Equipment, Aircraft
MIL-D-28728	Dial, Control, Multiturn Counters, General Specification for

3. Classification. Controls are classified as follows:

a. Operating controls. Operating controls are controls that may be required for use during the normal operation of the equipment.

b. Adjustment controls. Adjustment controls are controls that are used for alignment and calibration of the equipment and are not used during normal operation of the equipment.

4. Display. All controls shall be marked, indexed, sized, and located in such manner that the control position can be readily identified. Controls shall have fixed guide marks if presetting of the controls is required.

5. Arrangement and location. Controls shall be arranged to facilitate smooth and rapid operation. All controls which have sequential relations, which are related to a particular function or operation, or which are operated together shall be grouped together along with their associated displays. Controls shall be conveniently located with respect to associated visual displays. Controls located adjacent to their associated displays shall be so positioned that operation of the control will not obscure the display. Controls shall be of such size and so spaced that the manipulation of a given control does not interfere with the setting of an adjacent control. Adjustment controls with required test points shall be grouped and so marked as to provide for simplicity and ease of maintenance. When the activation of a given control may be hazardous to the equipment or operator, safeguards shall be provided.

6. Direction of movement. Controls shall be so connected in the circuit that the controlled characteristics (e. g., sensitivity, volume, or voltage) increase with clockwise rotation of the control as seen from the operating position. In general, movement of a control forward, clockwise, to the right, or up, shall turn the equipment on, cause the quantity to increase or cause the equipment to move forward, clockwise, to the right or up.

7. Accessibility

7.1 Operating controls. Controls necessary for the operation of the equipment shall be readily accessible, and unless otherwise specified shall be located on the front panel of the unit.

7.2 Adjustment controls. Adjustment controls that are required for periodic alignment or calibration shall be mounted behind covered openings such as access doors, on the faces of the equipment most accessible when installed. When not adjustable by hand, controls shall be designed to accept a common screwdriver blade tip. Controls which infrequently require adjustment need not be accessible from the operating panel, but shall be readily accessible for servicing when the equipment is opened for maintenance purposes. Unless otherwise specified, infrequently required controls should be screwdriver adjusted.

8. Mechanical characteristics

8.1 Operation. Play and backlash in controls shall be held to a minimum commensurate with intended operational functions and shall not cause poor contact or inaccurate setting. Contols shall operate freely and smoothly without binding, scraping, or cutting. Controls may be lubricated when lubrication does not interfere with operation and is specified in the detail equipment specification.

8.2 Stops. Mechanical stops shall be provided for all adjustable controls, except controls designed for unlimited rotation. Where flexible control shafts are employed, or where stops integral to the adjustable control or the mechanism could be damaged by excessive torque, stops shall be provided on the driving end of the shaft.

8.3 Locking devices. Control locking devices shall be capable of retaining the controls in any given setting within the range of control. The locking and unlocking action shall be easily and quickly accomplished, and shall not affect the setting of the control. When in the unlocked position, the locking devices shall not interfere with the normal operation of the control. Where vernier controls are used, the locking devices shall operate on both main and vernier controls if necessary to prevent damage.

8.4 Nonturn devices. All nonturning controls and bodies or cases of turning controls shall be equipped with a positive device to prevent their turning in the panel or assembly on which they are mounted.

8.5 Shafts and couplings. Control shafts and couplings shall be of such design and strength as to be commensurate with their respective loads. Coupling between or to shafts shall be accomplished by means of metallic or insulated couplings rigidly secured. Shafts subject to removal may have their couplings secured by two set screws 90 to 120 degrees apart. Flexible couplings will be permitted for controls where the use of rigid couplings would interfere with the satisfactory operation or mounting of such controls, except that flexible couplings shall not be employed for frequency determining circuits.

8.6 Control knobs and handles. Control knobs and handles shall have high impact strength and shall be firmly secured to the control shafts by use of setscrews wherever that type of fastener is applicable. Plastic knobs and handles shall have metal inserts for setscrews and shall not warp or crack. Control knobs conforming to MIL-K-3926 or MIL-K-25049 shall be used wherever suitable. For knobs not covered by a military specification, color, tactile information, and flammability requirements shall be in accordance with MIL-K-3926.

8.7 Multiturn counters control dials. Manually operated multiturn counters control dials shall conform to MIL-D-28728.

8.8 Stability. All controls shall be so designed that the setting, position, or adjustment of any control shall not be altered when the equipment is subjected to the service conditions specified in the detail equipment specification.

8.9 Construction. Switches, levers, and other controls which are manipulated during operation of the equipment shall be of such rugged design and construction that they will not be damaged when repeatedly operated by unskilled personnel under the specified service conditions.

9. Factory adjustment controls. The design of equipment shall not include "factory" or sealed adjustment controls, unless specifically approved by the detail equipment specification.

REQUIREMENT 29

ELECTRON TUBES

1. Purpose. This requirement establishes the criteria for the choice, specification, and application of electron tubes.

2. Document applicable to Requirement 29:

MIL-STD-200 Electron Tubes, Selection and Use of

3. Selection and application. Electron tubes shall be selected and applied in accordance with MIL-STD-200.

3.1 Electron tubes in equipment. Each unit of equipment using electron tubes shall be furnished with a complete set of electron tubes properly installed therein. These electron tubes shall be the electron tubes used in testing the unit and each tube (unless separate packaging of the tube is specified) shall remain in the socket which it occupied during the tests.

3.2 Subminiature tubes used in nonrepairable modules. Subminiature electron tubes shall be soldered or welded into the circuit.

REQUIREMENT 30

SEMICONDUCTOR DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of semiconductor devices.

* 2. Documents applicable to Requirement 30:

MIL-S-19500	Semiconductor Devices, General Specification for
MIL-STD-701	Lists of Standard Semiconductor Devices
MIL-STD-1547	Parts, Materials, and Processes for Space and Launch Vehicles, Technical Requirements for

* 3. Selection and application. Semiconductor devices shall be selected and applied in accordance with MIL-STD-701 and, for Space Division, AFSC (SD), MIL-STD-1547.

* 3.1 JANS levels. JANS level devices shall be used in space, launch, and reentry equipment applications for Space Division AFSC (SD). When JANS parts are not available, parts shall be specified/procured in accordance with the requirements of MIL-STD-1547.

* 3.2 JANTX and JANTXV levels. Only JANTX and JANTXV level devices shall be used in Army Missile Command, Army Electronics Research and Development Command, Naval Air Systems Command and Air Force applications other than SD space, launch, and reentry equipment. When these are not available, the devices selected, including JAN types, shall be process conditioned, tested, and screened (including Group A and B LTPD quality levels of MIL-S-19500) equivalent to the TX requirements for similar types.

4. Sealing. All semiconductor devices used in equipment shall be hermetically sealed in glass, metal, metal oxide, ceramic, or combinations of these. No plastic (organic or polymeric) encapsulated or sealed devices shall be used without the approval of the procuring activity.

5. Electrostatic sensitive parts. Certain types of semiconductor devices are susceptible to electrostatic discharge damage. Appropriate discharge procedures should be observed prior to handling these parts, and design selections of desired devices should include a consideration of the effectiveness of the input or other protective elements included in the device design.

REQUIREMENT 31

MOISTURE POCKETS

1. Purpose. This requirement establishes criteria for the treatment and drainage of moisture pockets.

2. Pockets, wells, traps, and the like in which water or condensate could collect when the equipment is in normal position shall be avoided, where practicable.

3. Where moisture pockets are unavoidable and the equipment is not sealed, provision shall be made for drainage of such pockets. Desiccants or moisture-absorbent materials shall not be used within moisture pockets.

4. Where moisture buildup cannot be tolerated in sealed equipment or assemblies such as waveguides, the use of desiccants or other methods, such as gas purging, should be considered.

REQUIREMENT 32

TEST PROVISIONS

1. Purpose. This requirement establishes criteria for test provisions.

2. Document applicable to Requirement 32:

MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for

3. Test provisions. Test provisions to provide means for monitoring performance, calibration, and fault isolation shall be in accordance with MIL-STD-415.

3.1 Built-in test devices. Built-in test devices shall maintain their accuracy under all operating conditions required by the equipment. These devices shall be provided with connections or access for their operational checkout or calibration.

3.2 External test points. Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points.

3.3 Failure effect. Provisions for testing shall be so designed that any failure of built-in test devices will not degrade equipment operation or cause equipment shut down unless equipment is specifically designed to shut down in case of built-in test device failure.

REQUIREMENT 33

RESISTORS

1. Purpose. This requirement establishes criteria for the selection and application of resistors.

2. Documents applicable to Requirement 33:

MIL-T-23648	Thermistor (Thermally Sensitive Resistor), Insulated, General Specification for
MIL-R-55342	Resistors, Fixed, Film, Chip, Established Reliability, General Specification for
MIL-STD-199	Resistors, Selection and Use of

3. Selection. Resistors shall be selected and applied in accordance with MIL-STD-199.

4. Thermistors. Thermistors shall conform to MIL-T-23648.

5. Fixed film chip. Fixed film chip resistors shall conform to MIL-R-55342.

REQUIREMENT 34

NOMENCLATURE

1. Purpose. This requirement establishes criteria for nomenclature (item name and type designation).

2. Document applicable to Requirement 34:

MIL-STD-196 Joint Electronics Type Designation Systems

3. Item names and type designations. Item names and type designations shall be established for electronic equipment in accordance with MIL-STD-196.

4. Limitation on type designation approval. The assignment of type designations shall not constitute approval of equipment or the use of a particular item in a specific set and shall not waive any requirements of the contract involved, nor does the approval of the equipment constitute approval of the type designation assignment.

REQUIREMENT 35

RELIABILITY

* 1. Purpose. This requirement offers direction as to reliability requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Reliability program tasks, quantitative requirements, and verification or demonstration requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

* 2. Documents applicable to requirement 35:

MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-STD-756	Reliability Modeling and Prediction
MIL-STD-781	Reliability Design Qualification and Product Acceptance Tests: Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects and Criticality Analysis
MIL-HDBK-217	Reliability Prediction of Electronic Equipment

* 3. Realibility program. Reliability engineering and accounting tasks aimed at preventing, detecting, and correcting reliability design deficiencies, weak parts, and workmanship defects and providing reliability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient reliability program according to life cycle phase. MIL-STD-785 is the overall program document for the area. It is sectionalized into individual task statements and requires extensive tailoring when it is applied. Detailed application guidance as to the nature of the tasks and when they should be imposed is provided. Other reliability documents which may be invoked through MIL-STD-785 or which may be cited directly as a basis for contract requirement include MIL-STD-721, MIL-STD-756, MIL-STD-781, MIL-STD-1629, and MIL-HDBK-217.

* 4. Quantitative requirements. Quantitative reliability requirements and verification or demonstration requirements should be established appropriate to program phase.

REQUIREMENT 36

ACCESSIBILITY

1. Purpose. This requirement establishes criteria for accessibility.

2. Documents applicable to Requirement 36:

MIL-STD-280	Definition of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-721	Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Definitions

3.1 Accessibility. Accessibility is as defined in MIL-STD-721.

3.2 Part, subassembly, and assembly. Part, subassembly, and assembly are as defined in MIL-STD-280.

4. Compatibility. Equipment shall be designed for optimum accessibility compatible with operating, maintenance, electromagnetic compatibility, and enclosure requirements.

5. Access. Each article of equipment and each major subassembly forming a part thereof shall provide for the necessary access to its interior parts, terminals, and wiring for adjustments, required circuit checking, and the removal and replacement of maintenance parts. Accessibility for testing and replacement does not apply to parts located in nonrepairable subassemblies or assemblies. For routine servicing and maintenance, unsoldering of wires, wire harnesses, parts or assemblies shall not be required in order to gain access to terminals, soldered connections, mounting screws and the like. Inspection windows shall be provided wherever necessary. Sizes of openings, maximum reach requirements, and allowable sizes and weights of replaceable assemblies shall conform to limits established in MIL-STD-1472.

6. Connections. Connections to parts inside a removable container shall be arranged to permit removal of the container without threading connection leads through the container.

7. Parts. Parts which are identified as replaceable parts for the equipment shall be easily removable and replaceable. These parts shall not be mounted by means of rivets, spot welding, or hard curing compounds. If, in order to check or remove a part, it is necessary to displace some other part, the latter part shall, whenever practicable, be so wired and mounted that it can be moved without being disconnected and without causing circuit detuning or instability. No unsoldering or soldering of connections shall be necessary when the front panel or any subchassis is removed for maintenance purposes. Design shall be

such that where plug-in modules or assemblies are used, they can be easily inserted in the proper location when correctly oriented without damage to equipment or parts being engaged. Plug-in modules and assemblies shall be designed to prevent insertion when incorrectly oriented.

8. Enclosures. Accessibility to chassis, assemblies, or parts contained within cabinets, consoles or other enclosures shall be provided from outside the basic equipment through the use of access doors, by mounting such items on withdrawal slides, swinging doors, through cable extenders and cable retractors, provisions for circuit card extenders which will allow part or module operation in the open position, or other arrangements to permit adequate access for properly servicing the equipment. Automatic or manually operated locks shall be provided to lock the chassis in the servicing position. When withdrawal slides are used they shall be of guided sectional construction with tracks and rollers. Complete removal and access for servicing of electronic equipment contained within cabinets, consoles or other enclosures shall be provided from either the front or rear of the equipment. Guide pins (or locating pins), or the equivalent, shall be provided for mechanical alignment during mounting. Shipboard equipment shall have complete access for maintenance and servicing from the front of the equipment.

REQUIREMENT 37

CIRCUIT BREAKERS

1. Purpose. This requirement establishes criteria for the selection and application of circuit breakers.

2. Documents applicable to Requirement 37:

W-C-375	Circuit Breaker, Molded Case; Branch-Circuit and Service
MIL-C-55629	Circuit Breaker, Magnetic, Low Power, Unsealed, Trip-Free, General Specification for
MIL-C-83383	Circuit Breakers, Remote Control, Thermal, Trip-Free
MIL-STD-1498	Circuit Breakers, Selection and Use of

3. Selection and application. Circuit breakers shall be selected from MIL-STD-1498 or shall conform to MIL-C-55629 or MIL-C-83383. Circuit breakers conforming to W-C-375 may be used where commercial power sources are utilized. Trip-free circuit breakers shall be used unless otherwise specified or approved by the procuring activity. Nontrip-free circuit breakers shall be used only when the application requires overriding of the tripping mechanism for emergency use.

3.1 Manual operation. Circuit breakers shall be capable of being manually operated to the ON and OFF positions.

3.2 Internal access. Access to the internal mechanism of a circuit breaker shall require the breaking of a seal.

3.3 Position identification. Circuit breakers shall have easily identified ON, OFF and TRIPPED positions except that the TRIPPED position may be the same as the OFF position with no differentiation between OFF and TRIPPED being required.

3.4 Orientation. Circuit breakers shall operate when permanently inclined in any direction up to 30 degrees from the normal vertical or normal horizontal position. The rated point of an inclined unit shall not vary more than ±5 percent of the current specified for normal position mounting. Circuit breakers used on flight equipment and portable test equipment shall operate within the limits of the detail specification when the equipment is in any position or rotation about its three principal axes.

3.5 Vertical mounting. Vertically mounted circuit breakers with toggle handle actuators shall have the ON position upward.

3.6 Insulating materials. Insulating materials used in the construction of circuit breakers shall neither support combustion nor give off noxious gases when subjected to the electrical arcing found in circuit breakers. Insulating materials subjected to arcing on instantaneous high current tripping shall be nontracking when subjected to the specified current limit.

3.7 Dielectric withstanding voltage. The dielectric withstanding voltage shall be not less than 1,000 volts plus twice the nominal operating voltage.

3.8 Insulation resistance. Unless otherwise specified, insulation resistance shall be 100 megohms or more.

REQUIREMENT 38

QUARTZ CRYSTAL UNITS

1. Purpose. This requirement establishes criteria for the selection of quartz crystal units.

2. Documents applicable to Requirement 38:

MIL-STD-683 Crystal Units, Quartz; and Holders, Crystal

3. Selection. Quartz crystal units shall be selected in accordance with MIL-STD-683.

REQUIREMENT 39

FUSES, FUSE HOLDERS, AND ASSOCIATED HARDWARE

1. Purpose. This requirement establishes criteria for the selection and application of fuses, fuse holders, and associated hardware.

2. Document applicable to Requirement 39:

MIL-STD-1360	Fuses, Fuseholders, and Associated Hardware, Selection and Use of

3. Selection and application. Fuses, fuseholders, and associated hardware shall be selected from MIL-STD-1360. Fusing shall be so arranged that fuses in branch circuits will open before the fuses in the main circuit. Fuses are not intended to perform the function of thermal overload relays or circuit breaker devices. Fuses shall have ratings which correspond to those of the parts and wiring they protect. Fuse ratings shall be compatible with both starting and operating currents. All fuses shall be easily replaceable. Connections to extractor post type fuse holders shall be such that the load is connected to the fuse terminal which terminates in the removable cap assembly.

4. Marking. The ampere rating of all fuses used in the equipment shall be indicated adjacent to the fuse holder in letters at least 3/64 inch high. In addition, "SPARE" shall be marked adjacent to each spare fuse holder.

REQUIREMENT 40

SHUNTS

1. Purpose. This requirement establishes criteria for the selection of external meter shunts.

2. Documents applicable to Requirement 40:

MIL-S-61	Shunt, Instrument, External, 50 millivolt (Lightweight Type)
MIL-I-1361	Instrument Auxiliaries, Electrical Measuring; Shunts, Resistors, and Transformers

3. Shunts. External meter shunts shall conform to MIL-S-61 or MIL-I-1361, as applicable.

REQUIREMENT 41

SPRINGS

1. Purpose. This requirement establishes criteria for the design, selection, and application of springs.

2. Documents applicable to Requirement 41:

QQ-B-750	Bronze, Phosphor, Bar, Plate, Rod, Sheet, Strip, Flat Wire and Structural and Special Shaped Sections
QQ-C-530	Copper-Beryllium Alloy, Bar, Rod, and Wire (Copper Alloy Numbers 172 and 173)
QQ-C-533	Copper-Beryllium Alloy Strip (Copper Alloy Numbers 170 and 172)
QQ-C-585	Copper-Nickel-Zinc Alloy Plate, Sheet, Strip and Bar (Copper Alloy Numbers 735, 745, 752, 762, 766, and 770)
QQ-C-586	Copper-Nickel-Zinc Alloy; Rod Shapes, and Flat Products and Finished Edges (Flat Wire, Strip, and Bar)
QQ-S-766	Steel Plates, Sheets, and Strip, Corrosion Resisting
QQ-W-321	Wire, Copper Alloy
QQ-W-423	Wire, Steel, Corrosion-Resisting
QQ-W-470	Wire, Steel, Carbon, Spring, Music
MIL-S-7947	Steel, Sheet and Strip (1095) Aircraft Quality
MIL-S-13282	Silver and Silver Alloy
MIL-S-13572	Spring, Helical, Compression and Extension
MIL-C-19311	Copper-Chromium Alloy Forgings, Wrought Rod, Bar and Strip (Copper Alloy Numbers 182, 184 and 185)
MIL-S-22215	Silver-Copper-Cadmium-Nickel Alloy
MIL-S-46049	Steel, Carbon, Strip, Cold Rolled, Hardened and Tempered, Spring Quality
MIL-E-46065	Electrical Contact Alloys, Precious Metals (Gold, Palladium, Platinum, and Iridium
MIL-C-81021	Copper-Cobalt-Beryllium Alloy (Copper Alloy No. 175), Strip
ASTM A29-74	Steel Bar, Carbon and Alloy, Hot Rolled and Cold Finished, General Requirements for
ASTM A682-73	Steel, Carbon, Strip, Cold Rolled Spring Quality, General Requirements
ASTM A684-73	Steel, Carbon, Strip, Cold Rolled Soft, Untempered Spring Quality

Metals Handbook, Vol I (1961), American Society for Metals

3. Spring performance and design

3.1 Fatigue limits. Fatigue limits and, in the case of contact springs, electrical conductivity of the springs shall not be adversely affected by corrosion, operating temperature, and other environmental conditions in service. Fatigue limits shall be consistent with the maximum specified operating cycles for the respective part or equipment or, if such is not specified, with the maximum duty cycle reasonably to be expected during the equipment service life, so as to ensure against premature failure.

3.2 Design. Springs shall be enclosed or otherwise captivated, where practicable, to prevent parts from becoming adrift if broken.

3.3 Heat treatment. Springs made of materials that achieve their desired properties by heat treatment, such as copper-beryllium alloys, annealed carbon steels, CRES steels, or heat resisting alloys, shall be heat treated to the specified temper after forming.

3.4 Grain orientation. Flexure and forming of spring elements should be designed to occur perpendicular to the grain of the material. Deviation from the perpendicular shall not exceed 45 degrees. This requirement applies to springs whether heat treated or not.

3.5 Helical springs. Helical springs shall conform to MIL-S-13572.

4. Documents for specifying materials. When the materials listed in table 41-I, 41-II, and 41-III are used, they shall conform to the specifications listed for each material. Electrical contact springs shall use materials selected from table 41-I.

5. Finishes. Carbon steel springs shall be suitably plated or finished to resist corrosion.

Table 41-I. Springs for Electrical Application

Material	Form	Material specification
Copper-nickel-zinc alloy	Plate, sheet, strip and rolled bar	QQ-C-585
Copper-nickel-zinc alloy	Rod, shapes and flat products with finished edges (flat wire, strip and bar)	QQ-C-586
Copper-beryllium alloy	Bars, rods, and wire	QQ-C-530
Copper-beryllium alloy	Strip	QQ-C-533
Copper alloy	Wire, spring	QQ-W-321
Copper-cobalt-beryllium alloy	Strip	MIL-C-81021
Copper-chromium alloy	Bar, rod, and strip	MIL-C-19311
Phosphor bronze	Bar, rod, plate, sheet, strip, and flat wire	QQ-B-750
Platinum-iridium alloy	Strip	MIL-E-46065
Silver-copper alloy	Bar, rod, plate, sheet, strip, and wire	MIL-S-13282
Silver-copper-cadmium-wire nickel-alloy	Rod, sheet, strip, and	MIL-S-22215
Palladium-copper alloy		Metals Handbook, Vol I

Table 41-II. Corrosion Resisting Steel Springs 1/

Material	Form	Material specification
Steel, CRES	Wire Strip	QQ-W-423 QQ-S-766

1/ Corrosion resisting steel springs are preferred where electrical conductivity is not a consideration and where they are adequate for the purpose intended.

Supersedes
REQUIREMENT 41
1 February 1977

REQUIREMENT 41
15 August 1981

Table 41-III. Carbon Steel Springs

Material	Form	Material specification
Steel, high carbon	Wire, spring, music	QQ-W-470 1/
Steel, carbon and alloy (for springs)	Strip, cold rolled untempered spring	ASTM A682-73 ASTM A684-73
Steel, carbon and alloy (for springs)	Bars, round, square and flat	ASTM A29-74
Steel, carbon, strip	Cold rolled, hardened and tempered spring	MIL-S-46049
Steel, carbon (1095)	Sheet and strip A-annealed (condition 1) H-hard temper (condition 3) cold finished	MIL-S-7947

1/ QQ-W-470 springs require heat treatment immediately after forming to prevent stress embrittlement.

REQUIREMENT 42

TUNING DIAL MECHANISMS

1. Purpose. This requirement establishes criteria for the design and construction of tuning dial mechanisms.

2. Documents applicable to Requirement 42:

MIL-S-3644	Shaft Assembly, Flexible
MS33558	Numerals and Letters, Aircraft Instrument Dial, Standard Form of

3. Tuning dial mechanisms. Tuning dial mechanisms shall conform to the following:

3.1 Dials. The division marking and lettering on tuning dials shall be suitably etched or printed with characters of style MS33558. Dial markings shall be legible at a distance of two feet from any point within a solid angle of 60 degrees defined by a surface of revolution about a line through the center of the dial and perpendicular to the panel. Minimum space between characters shall be one stroke width. The width of the lubber line or pointer tip shall not exceed the width of the graduation marks. Except for digital tuning indicators, for which only one calibration number will be seen, dials shall be marked so that at least two calibration numbers on each band can be seen at any dial setting.

3.2 Balance and friction. Weighted tuning knobs shall be counterbalanced. Friction in tuning dial mechanisms shall allow smooth and easy adjustment of the operating knob over the entire operating range of the mechanism, but shall have sufficient resistance or shall incorporate a positive locking device to maintain the setting under all specified service conditions. Friction shall be achieved through dry or elastic resistance rather than by fluid resistance.

3.3 Flexible control shafts. Flexible shaft assemblies conforming to MIL-S-3644 shall be used when a flexible mechanical connection is required between the tuning knob and the tuned device.

3.4 Tuning ratio. The tuning ratio used shall be the optimum which will permit both rapid and precise setting.

REQUIREMENT 43

LUBRICANTS

1. Purpose. This requirement establishes criteria for the selection and application of lubricants.

2. Documents applicable to Requirement 43:

VV-L-800	Lubricating Oil, General Purpose, Preservative (Water-Displacing, Low-Temperature)
VV-P-236	Petrolatum, Technical
MIL-L-2105	Lubricating Oil, Gear, Multi-Purpose
MIL-L-3150	Lubricating Oil, Preservative, Medium
MIL-L-3918	Lubricating Oil, Instrument, Jewel Bearing
MIL-L-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility
MIL-L-6086	Lubricating Oil, Gear, Petroleum Base
MIL-L-15719	Lubricating Grease (High-Temperature, Electric Motor, Ball and Roller Bearings)
MIL-L-17331	Lubricating Oil, Steam Turbine (Noncorrosive)
MIL-L-17672	Lubricating Oil, Hydraulic and Light Turbine, Noncorrosive
MIL-G-18709	Grease, Ball and Roller Bearing (Navy)
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw
MIL-G-24139	Grease, Multipurpose, Quiet Service
MIL-L-27694	Lubricating Oil, Instrument, Minus 65 Deg to Plus 400 Deg F
MIL-G-81322	Grease, Aircraft, General Purpose, Wide Temperature Range

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Lubricants. Lubricants used in equipment shall be suitable for the purpose intended and shall conform to the following.

3.1 Variety. The number of different lubricants shall be held to a minimum.

3.2 Volatility. Low volatility lubricants shall be used where practical.

3.3 Compatibility. The lubricant shall be chemically inert with regard to the materials it contacts.

3.4 Silicones. Unless approved by the procuring activity, silicone compounds shall not be used as lubricants.

3.5 Graphite base lubricants. Graphite base lubricants shall not be used.

4. Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

Supersedes
REQUIREMENT 43
26 September 1977

REQUIREMENT 43
15 August 1981

5. Lubricant specifications. Lubricants shall conform to the following:

VV-L-800	MIL-L-6085	MIL-G-18709
VV-P-236	MIL-L-6086	MIL-G-23827
MIL-L-2105	MIL-L-15719	MIL-G-24139
MIL-L-3150	MIL-L-17331	MIL-L-27694
MIL-L-3918	MIL-L-17672	MIL-G-81322

REQUIREMENT 44

FIBROUS MATERIAL, ORGANIC

1. Purpose. This requirement establishes criteria for the selection and application of organic fibrous material.

2. Documents applicable to Requirement 44:

V-T-276	Thread, Cotton
V-T-285	Thread, Polyester
V-T-291	Thread, Linen
V-T-295	Thread, Nylon
CCC-C-428	Cloth, Duck, Cotton; Fire, Water, Weather, and Mildew Resistant
MIL-W-530	Webbing, Textile, Cotton, General Purpose, Natural or in Colors
MIL-C-572	Cords, Yarns, and Monofilaments, Organic Synthetic Fiber
MIL-T-3530	Thread and Twine, Mildew Resistant or Water Repellant Treated
MIL-W-4088	Webbings, Textile, Woven Nylon
MIL-C-9074	Cloth, Laminated, Sateen, Rubberized
MIL-W-27265	Webbing, Textile, Woven Nylon, Impregnated

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.

3. Fabric and thread. Unless otherwise specified by the procuring activity, fabric and thread shall conform to the following.

3.1 General. The color of fabric or thread shall be as specified in the detail product specification or by the procuring activity. Fabric and thread shall be preshrunk, or allowance shall be made for shrinkage in order to provide for satisfactory fit of finished items both before and after they are immersed in water and then dried.

3.2 Webbing

3.2.1 Cotton. Cotton webbing shall conform to MIL-W-530, class 4 or 7. Class 7 shall be used when webbing will come in contact with natural or synthetic rubber, or class 4 when prolonged contact with the skin may occur.

3.2.2 Nylon. Nylon webbing shall conform to MIL-W-4088 or class R of MIL-W-27265.

3.3 Cotton duck. Cotton duck used for protective enclosures shall conform to type I or type II of CCC-C-428. Medium texture number 4 shall be used for heavy duty service and hard texture number 12 shall be used for services requiring light weight.

3.4 Thread. Thread shall conform to the following:

V-T-276	Thread, Cotton
V-T-285	Thread, Polyester
V-T-291	Thread, Linen
V-T-295	Thread, Nylon

3.4.1 Treatment. Cotton and linen shall be treated in accordance with MIL-T-3530. Type I, class 2 mildew inhibiting agent shall be used when thread

will come in contact with natural or synthetic rubber, or type I, class 1 when prolonged contact with the skin may occur.

3.5 Sateen. Laminated, two-ply rubberized cotton sateen shall conform to MIL-C-9074. This sateen shall not be used when prolonged contact with the skin may occur.

3.6 Cords, yarns, and monofilaments. Cords, yarns, and monofilaments shall conform to MIL-C-572. Types PVCA, AR, VCR, and CTA shall not be used where they may be exposed to fungus attack.

4. Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

REQUIREMENT 45

CORONA AND ELECTRICAL BREAKDOWN PREVENTION

1. Purpose. This requirement establishes criteria for prevention of corona and electrical breakdown.

2. Document applicable to Requirement 45:

ASTM D1868-73 Detection and Measurement of Discharge (Corona) Pulses in Evaluation of Insulation Systems

3. Corona prevention. When the equipment is terminated with the cabling or other accessory equipment with which it is intended to be used, and when operated under the specified service conditions of humidity, temperature, condensation and barometric pressure with the specified power source frequencies and voltages (including commonly recurring transients), the corona level shall be compatible with the specified electromagnetic interference requirements. The corona level shall not degrade the equipment performance beyond the specified limits and shall not produce long-term degradation of the properties of materials or parts which may cause premature failure of the equipment. The corona extinction voltage shall be at least 150 percent of the peak circuit voltage, corresponding to the maximum specified steady-state root mean square supply voltage, at any point which does not involve materials resistant to the effects of corona. Corona inception and extinction voltages shall be defined in accordance with ASTM D1868-73. Sharp edges and points should be avoided on all metal parts which are included in high-intensity electric fields. These are elements which contribute to formation of corona discharge.

4. Electrical breakdown prevention. The equipment shall be designed and manufactured with electrical clearance spacing, leakage (creepage) distances, and insulation levels adequate to prevent electrical breakdown under the specified service conditions of humidity, condensation, barometric pressure, temperature, service life, contamination, and operating voltage (including transients). Liquid dielectrics, gases other than ambient air, or pressurization to prevent electrical breakdown shall not be used unless specified by the detail equipment specification or approved by the procuring activity.

REQUIREMENT 46

MOTORS, DYNAMOTORS, ROTARY POWER CONVERTERS
AND MOTOR-GENERATORS

1. Purpose. This requirement establishes criteria for the selection and application of motors, dynamotors, rotary power converters, and motor-generators.

2. Documents applicable to Requirement 46:

CC-M-1807	Motors, Alternating Current, Fractional and Integral Horsepower (500 HP and Smaller)
MIL-D-24	Dynamotors, General Specification for
MIL-G-3111	Generator, Electric, Direct Current (Naval Shipboard Use)
MIL-G-3124	Generator, Alternating Current, 60 Cycle (Naval Shipboard Use)
MIL-M-4803	Motor-Generator, 400 Cycle, Precise Output, General Requirements for
MIL-M-4818	Motor-Generator, Skid Mounted, Type MD-2
MIL-M-4819	Motor-Generator, Skid Mounted, Type MD-3
MIL-M-4820	Motor-Generator, Skid Mounted, Type MD-4
MIL-M-7969	Motor, Alternating Current, 400 Cycle, 115/200-Volt System, Aircraft, General Specification for
MIL-M-8609	Motors, Direct Current, 28 Volt System, Aircraft, General Specification for
MIL-M-9397	Motor-Generator, Mobile, Type MC-1A
MIL-R-10761	Rotary Converters (Motor Generators), PU-134/u, PU-140/u, PU-141/u, and PU-143/u
MIL-M-13786	Motors, Fractional Horsepower, Direct Current and Universal (for Communication and Other Electronic and Special Military Applications)
MIL-M-13787	Motors, Alternating Current, Fractional Horsepower, Squirrel Cage (for Communication and Other Electronic and Special Military Applications)
MIL-M-17059	Motor, 60 Cycle, Alternating Current, Fractional Horsepower (Shipboard Use)
MIL-M-17060	Motors, 60 Cycle, Alternating Current, Integral Horsepower (Shipboard Use)
MIL-M-17413	Motors, Direct Current, Integral Horsepower, Naval Shipboard
MIL-M-17556	Motor, Direct Current, Fractional Horsepower, (Shipboard Use)
MIL-M-19097	Motor-Generators, DC to AC, Shipboard Service
MIL-M-19160	Motor-Generator, 60 Cycle AC to 400 Cycle AC, Shipboard Service
MIL-M-19167	Motor-Generators, AC to DC, Shipboard Service
MIL-M-19283	Motor-Generator, DC to DC, Shipboard Service
MIL-M-19633	Motor-Generator, 60 Cycle AC to 400 Cycle AC (Voltage and Frequency Regulated) Shipboard Service
MIL-B-23071	Blower, Miniature, For Cooling Electronic Equipment (10 to 500 Cfm), General Specification For

Supersedes
REQUIREMENT 46
1 February 1977

REQUIREMENT 46
15 August 1981

3. Electromagnetic compatibility. Motors, dynamotors, rotary power converters, and motor generators used in the equipment shall meet the electromagnetic compatibility requirement specified in the detail equipment specification.

4. Motors - alternating current. Alternating current motors shall conform to CC-M-1807, MIL-M-7969, MIL-M-13787, MIL-M-17059 or MIL-M-17060, except that any motor used with a miniature blower for cooling electronic equipment shall be in accordance with MIL-B-23071. Other motors may be used where uniquely required by the design of the equipment, provided they meet the applicable requirements of the specification covering that type of motor and the additional requirements of the detail equipment specification.

5. Motors - direct current. Direct current motors shall conform to MIL-M-8609, MIL-M-13786, MIL-M-17413 or MIL-M-17556. Other motors may be used where uniquely required by the design of the equipment, provided they meet the applicable requirements of the specification covering that type of motor and the additional requirements of the detail equipment specification.

6. Motor-generators. Motor-generators shall conform to one of the following or shall be as specified in the detail equipment specification.

MIL-M-4803	MIL-M-9397	MIL-M-19167
MIL-M-4818	MIL-R-10761	MIL-M-19283
MIL-M-4819	MIL-M-19097	MIL-M-19633
MIL-M-4820	MIL-M-19160	

7. Generators - alternating current. Alternating current generators shall conform to MIL-G-3124 or shall be as specified in the detail equipment specification.

8. Generators - direct current. Direct current generators shall conform to MIL-G-3111 or shall be as specified in the detail equipment specification.

9. Dynamotors. Dynamotors shall conform to MIL-D-24.

REQUIREMENT 47

ENCAPSULATION AND EMBEDMENT (POTTING)

1. Purpose. This requirement establishes criteria for encapsulating and embedding (potting) a part or an assembly of discrete parts. Conformal coating of printed circuit assemblies is excluded from this requirement.

2. Documents applicable to Requirement 47:

MIL-S-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-I-16923	Insulating Compound, Electrical, Embedding
MIL-S-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-M-24041	Molding and Potting Compound, Chemically Cured, Polyurethane (Polyether Based)
MIL-P-47298	Polyurethane Molding Compound, Chemically Cured (Polyether Based)
MIL-I-81550	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
MIL-P-83455	Potting Compound, Two-Component, RTV, Fluorosilicone

Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. The following definitions apply.

3.1 Encapsulation. A process for encasing a part or an assembly of discrete parts within a protective material which is generally not over 100 mils thick and does not require a mold or container.

3.2 Embedment (potting). A process for encasing a part or an assembly of discrete parts within a protective material which is generally over 100 mils thick, varies in thickness, fills the connecting areas within an assesmbly, and requires a mold or container to confine the material while it is hardening. Potting is an embedding process where the protective material bonds to the mold or container so that it becomes integral with the item.

4. Selection of material: The encapsulation and embedment materials shall be selected on the basis of the item(s) being encased. The manufacturer's instructions for mixing, method of application, and curing shall be followed. The materials shall be capable of filling all voids and air spaces in and around the item(s) being encased. The following points shall be considered when selecting an encapsulation or embedment material:

a. Need for precautions due to hazardous characteristics of the material

b. Electrical, mechanical and thermal properties, including tear resistance, resistance to flame, chemicals, moisture, water, humidity, fungus, and temperature extremes

c. Color or transparency

d. Dissipation factor

e. Specific gravity

f. Shrinkage

g. Heat distortion parameters

h. Stresses on parts

i. Durometer hardness

j. Adhesion to substrates (and priming)

k. Temperatures of application and curing

l. Repairability

m. Dielectric constant

n. Volume resistivity

o. Reversion resistance, including hydrolytic stability

p. Viscosity

q. Solvent effects.

4.1 Materials. Materials shall be of a nonreversion type and shall be selected from the following specifications: MIL-S-8516, MIL-I-16923, MIL-S-23586, MIL-M-24041, MIL-P-47298, MIL-I-81550, and MIL-P-83455. For Air Force applications, approval for use of any material not listed here shall be requested through the procuring activity from the Air Force Wright Aeronautical Laboratories, ATTN: MLSE, Wright Patterson AFB OH 45433.

4.2 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance shall be given prior to material selection.

5. Limitations. Materials used for encapsulation and embedment of parts and assemblies shall be in accordance with applicable design requirements. Such materials shall have no deleterious effect on the part or assembly to which they are applied. The materials shall be contained, if necessary, to prevent flow or cracks under the specified storage or operating environment.

6. Application. No encapsulation or embedment materials shall be applied to an individual part except as part of the controlled production process for that part. The encapsulation or embedment of microelectronic modules and equipment modules shall be avoided, except where specifically indicated by the requirements of a particular application. In such instances, the module design shall be completely verified for the particular encapsulation or embedment materials and processes to be employed. Any changes in module design, materials, and processes will require re-evaluation of the modules. In particular, extreme temperature aging and temperature cycling tests shall be performed to verify adequacy of the design. Wherever economically feasible, the module to be encapsulated or embedded shall be designed as a throw-away unit.

REQUIREMENT 48

GEARS

1. Purpose. This requirement establishes criteria for the selection and application of gears.

2. Documents applicable to Requirement 48:

Index American Gear Manufacturers Association (AGMA)

3. Design. The design of a gear train shall be such that the gear train system shall meet performance requirements throughout its specified life.

3.1 Where practicable, gears shall be designated, dimensioned, toleranced and inspected in accordance with the applicable AGMA specifications.

4. Planetary or epicyclic gearing. Planetary or epicyclic gearing is preferred to worm gearing where applicable.

5. Gear materials

5.1 Gears not operating in a lubricant bath shall be made of corrosion resistant materials.

5.2 Gears operating in a lubricant bath enclosure may be made of noncorrosion resistant materials. The lubricant shall have a corrosion inhibiting additive.

5.3 Unless otherwise specified by the procuring activity, nonmetallic gears may be used when they meet load, life, and environmental requirements of the applicable specification.

REQUIREMENT 49

HYDRAULICS

1. Purpose. This requirement establishes criteria for the design and installation of a hydraulic system when it functions as an integral part of an electronic system.

* 2. Documents applicable to requirement 49:

MIL-H-5440	Hydraulic Systems, Aircraft, Type I and II, Design, Installation, and Data Requirements for
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements for
MIL-H-25475	Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements, General Requirements for
ANSI B93.1-1964	Fluid Power Cylinders, Dimension Identification Code for (NFPA T3.2.60.1-1960)
ANSI B93.2-1971	Fluid Power, Glossary of Terms for (NFPA T2.70.1-1970)
ANSI B93.3-1968	Cylinder Bore and Piston Rod Sizes for Fluid Power Cylinders (NFPA T3.6.67.1-1967)
ANSI B93.4-1969	Electric Resistance Welded Mandrel Drawn Hydraulic Line Tubing (NFPA T3.15.67.1-1967)
ANSI B93.5-1973	Use of Fire-Resistant Fluids for Fluid Power Systems, Practices for the (NFPA T3.11.1R1-1972)
ANSI B93.6-1972	Mounting Flanges and Shafts for Positive Displacement Fluid Power Pumps and Motors, Dimensions and Identification Code for (NFPA T3.9.2R1)
ANSI B93.7-1968	Mounting Surfaces of Sub-Plate Type Hydraulic Fluid Power Valves, Dimensions for (NFPA T3.5.65.0-1965)
ANSI B93.8-1968	Bore and Rod Size Combinations and Rod End Configurations for Cataloged Square Head Industrial Fluid Power Cylinders (NFPA T3.6.67.4-1967)
ANSI B93.9-1969	Symbols for Marking Electrical Leads and Ports on Fluid Power Valves (NFPA T3.5.68.2-1968)
ANSI B93.10-1969	Static Pressure Rating Methods of Square Head Fluid Power Cylinders (NFPA T3.6.68.5-1968)
ANSI B93.11-1969	Seamless Low Carbon Steel Hydraulic Line Tubing (NFPA T3.15.67.2-1967)
ANSI SAE J514h	Hydraulic Tube Fittings
ANSI SAE J518c	Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Bolt, Split Flange Type

3. Aircraft or manned flight vehicles. The design and installation of hydraulic systems for aircraft or manned flight vehicles shall conform to the applicable type and class of system described in MIL-H-5440 or MIL-H-8891.

4. Missiles. The design and installation of hydraulic systems for missiles shall conform to the applicable type and class of system shown in MIL-H-25475.

5. Support or test equipment. The design and installation of hydraulic support or test equipment shall be capable of meeting the environmental and performance requirements specified by the procuring activity. Components shall be selected so that full compatibility with the system, for which the support or test equipment is being designed, is attained.

* 6. References. The following documents contain additional information on hydraulic design:

ANSI B93.1
ANSI B93.2
ANSI B93.3
ANSI B93.4
ANSI B93.5
ANSI B93.6
ANSI B93.7
ANSI B93.8
ANSI B93.9
ANSI B93.10
ANSI B93.11
ANSI SAE J514
ANSI SAE J518

REQUIREMENT 50

INDICATOR LIGHTS

1. Purpose. This requirement establishes criteria for indicator lights and associated items.

2. Documents applicable to Requirement 50:

W-L-111	Lamps; Electric Incandescent Miniature, Tungsten-Filament
W-L-116	Lamps, Fluoroescent
MIL-L-3661	Lampholder, Indicator Lights, Indicator-Light Housings, and Indicator-Light Lenses, General Specification for
MIL-L-6363	Lamps, Incandescent, Aviation Service, General Requirements for
MIL-L-7806	Light, Panel, Plastic Plate Lighting
MIL-L-7961	Lights, Indicators, Press to Test
MIL-L-15098	Lamp, Glow
MIL-S-19500	Semiconductor Device, General Specification for
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Lights and accessories. Indicator lights, indicator light housings, lampholders, lenses, and lamps shall conform to table 50-I.

4. Visual display and legend lights. Visual display and legend lights shall comply with the requirements in MIL-STD-1472.

5. Light emitting diodes (LED's). LED's when used as indicator lights shall conform to the applicable detail specifications of MIL-S-19500.

* Table 50-I. Indicator lights and associated items

	MIL-L-3661	MIL-L-7806	MIL-L-7961	MIL-L-6363	MIL-L-15098	MIL-S-19500	W-L-111	W-L-116
Indicator lights	X		X			X		
Indicator light housings	X							
Lamp holders	X	X						
Lenses	X							
Incandescent lamps				X			X	
Neon lamps					X			
Fluorescent lamps								X

Supersedes
REQUIREMENT 50
1 November 1974

REQUIREMENT 50
29 August 1980

REQUIREMENT 51

METERS, ELECTRICAL INDICATING, AND ACCESSORIES

1. Purpose. This requirement establishes criteria for the selection and application of electrical meters and meter accessories.

2. Documents applicable to Requirement 51:

MIL-M-7793	Meter, Time Totalizing
MIL-M-16034	Meter, Electrical Indication (Switchboard and Portable Types)
MIL-M-16125	Meters, Electrical, Frequency
MIL-I-81219	Indicator, Elapsed Time, Electrochemical
MIL-STD-1279	Meters, Electrical Indicating, Selection and Use of

3. Selection and application. Meters shall be selected and applied in accordance with MIL-STD-1279. Meters required other than those listed in MIL-STD-1279 shall conform to one of the following specifications: MIL-M-7793, MIL-M-16034, MIL-M-16125, MIL-I-81219. For analog meters, the normal operating value of the quantity to be indicated shall be between 1/3 and 3/4 of full scale deflection, wherever practicable.

4. Accessories. Meter accessories (resistors, transformers, and shunts) shall conform to the requirements of the applicable meter specification.

REQUIREMENT 52

THERMAL DESIGN

1. Purpose. This requirement establishes criteria for thermal design.

2. Documents applicable to Requirement 52:

F-F-300	Filter, Air Conditioning, Viscous-impingement and Dry Types, Cleanable
MIL-F-16552	Filter, Air Environmental Control System, Cleanable, Impingement (High Velocity Type)
MIL-B-23071	Blower, Miniature for Cooling Electronic Equipment (10 to 500 cfm), General Specification for
MIL-F-28717	Filter, Air, Viscous Impingement Type, Cleanable and Reusable, for Equipment Enclosures, and Impingement Oil; General Specification for
MIL-HDBK-251	Reliability/Design, Thermal Applications

3. Auxiliary heating or cooling. Auxiliary heating or cooling means or devices may be employed when the equipment is to be operated for prolonged periods for test and checkout purposes, when such periods are not consistent with normal operating requirements.

4. Forced air cooling. Forced air cooling shall be used only when natural cooling does not provide sufficient cooling or when a significant reduction in overall size and weight can be realized. Exhaust and recirculating fans and blowers shall be driven by brushless motors operating from the available ac power sources, if possible, or by properly shielded dc motors. The design factors to be considered in determining the required fan or blower characteristics include such factors as amount of heat to be dissipated, the quantity of air to be delivered at the pressure drop of the enclosed equipment, the allowable noise level, the permissible level of heat that may be exhausted into the surrounding environment, and other pertinent factors affecting the cooling requirement of the equipment. Miniature blowers shall conform to MIL-B-23071. Induced drafts and ventilation by means of baffles and internal vents shall be used to the greatest practicable extent. Air filters shall be provided for air intakes for fan and blower cooled units when required to protect internal parts. Filters, when used, shall conform to F-F-300, MIL-F-16552, or MIL-F-28717, and shall be readily removable for cleaning without disassembly of the equipment. All ventilation openings shall be designed and located to comply with electromagnetic interference, undesired radiation and enclosure requirements. When practicable, ventilation and air exhaust openings shall not be located in the top of enclosures or in front panels. Air exhaust shall be so directed that it will not inconvenience operating personnel.

4.1 For equipment thermally designed for use with external source supplied cooling air, which may contain entrained water or other contaminants detrimental to the equipment, precautionary measures shall be taken to avoid direct impingement on internal parts and circuitry by channeling or use of heat exchangers. If this is impractical, the water and contaminants shall be removed from the cooling air by suitable water and contaminant removal devices. Consistent with adequate cooling, minimum differential pressure (pressure drop) of the cooling air through the equipment heat exchanger or cold plate shall be maintained. Each separate piece of equipment being cooled shall be marked with the high and low operating temperature to which it is designed, the quantity and characteristics of air required to adequately cool the unit, and the resistance to air flow with respect to the air flow rate.

4.2 Equipment requiring externally supplied cooling air and intended for use in aircraft shall be designed using cold plates or heat exchangers so that none of the cooling air will come into contact with internal parts, circuitry, or connectors.

4.3 MIL-HDBK-251 may be used as a guide for detail information on thermal design of electronic equipment.

5. Other cooling methods. Unless approved by the procuring activity, other cooling methods such as liquid, evaporative coolants, and vapor cycle refrigerants shall not be used.

REQUIREMENT 53

WAVEGUIDES AND RELATED EQUIPMENT

1. Purpose. This requirement establishes criteria for the selection of waveguides and related equipment.

2. Documents applicable to Requirement 53:

MIL-W-287	Waveguide Assembly, Flexible, Twistable and Nontwistable
MIL-D-3954	Dummy Load, Electrical, Waveguide, General Specification for
MIL-W-3970	Waveguide Assemblies, Rigid, General Specification for
MIL-A-22641	Adapters, Coaxial to Waveguide, General Specification for
MIL-G-24211	Gasket, Waveguide Flange, General Specification for
MIL-A-24215	Attenuator, Variable (Coaxial and Waveguide), General Specification for
MIL-I-28791	Isolators, Radio Frequency, General Specification for
MIL-D-39030	Dummy Load, Electrical, Coaxial, General Specification for
MIL-S-55041	Switches, Waveguide
MIL-STD-1327	Flanges, Coaxial and Waveguide; and Coupling Assemblies, Selection of
MIL-STD-1328	Coupler, Directional (Coaxial Line, Waveguide and Printed Circuit), Selection of
MIL-STD-1329	Switches, RF Coaxial, Selection of
MIL-STD-1352	Attenuators, Fixed, Selection of
MIL-STD-1358	Waveguides, Rectangular, Ridged and Circular, Selection of
MIL-HDBK-216	RF Transmission Lines and Fittings
MIL-HDBK-660	Fabrication of Rigid Waveguide Assemblies (Sweep Bends and Twists)

3. General. Waveguides and related equipment shall be selected in accordance with table 53-I. MIL-HDBK-216 should be used as a guide wherever applicable. Waveguides and related equipment shall conform to a specification listed in table 53-I, or the appropriate specification in a standard listed in table 53-I.

3.1 Materials. When selecting parts, consideration shall be given to corrosion resistance of materials and the proper protection of dissimilar metal combinations.

3.2 Fabrication of rigid assemblies. MIL-HDBK-660 shall be used as a guide in the fabrication of rigid assemblies.

Table 53-I. Waveguides and Related Equipment

Waveguide or related equipment		Applicable document
Adapters	Coaxial to waveguide	MIL-A-22641
Attenuators	Fixed	MIL-STD-1352
	Variable	MIL-A-24215
Couplers, directional	Coaxial & Waveguide	MIL-STD-1328
Coupling assemblies	Quick disconnect (subminiature)	MIL-STD-1327
Flanges	Waveguide, rigid	
	Waveguide, ridged	
	Waveguide, flexible	
	Coaxial line	
Dummy loads	Coaxial	MIL-D-39030
	Waveguide	MIL-D-3954
Gaskets	Waveguide	MIL-G-24211
Isolators	Coaxial	MIL-I-28791
Switches	Waveguide	MIL-S-55041
	Coaxial, rf	MIL-STD-1329
Waveguide assemblies	Rigid	MIL-W-3970
	Flexible	MIL-W-287
Waveguides	Rigid	MIL-STD-1358
	Ridged	
	Circular	

REQUIREMENT 54

MAINTAINABILITY

* 1. Purpose. This requirement offers direction as to maintainability requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Maintainability program tasks, quantitative requirements, and verification or demonstration requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

* 2. Document applicable to requirement 54:

MIL-STD-470	Maintainability Program Requirements for Systems and Equipments
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-HDBK-472	Maintainability Prediction

* 3. Maintainability program. Maintainability engineering and accounting tasks aimed at preventing, detecting, and correcting maintainability design deficiencies and providing maintainability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient maintainability program document for the area. Other maintainability documents which may be invoked through MIL-STD-470 or which may be cited directly as a basis for contract requirements include MIL-STD-471, MIL-STD-721, and MIL-HDBK-472.

* 4. Quantitative requirements. Quantitative maintainability requirements and verification or demonstration requirements should be established as appropriate to program phase.

REQUIREMENT 55

ENCLOSURES

1. Purpose. This requirement establishes criteria for the design and construction of enclosures.

2. Documents applicable to Requirement 55:

MIL-C-172	Cases, Bases, Mounting, and Mounts, Vibration (For Use With Electronic Equipment in Aircraft)
MIL-M-81288	Mounting Bases, Flexible Plastic Foam
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-189	Racks, Electrical Equipment, 19 inch and Associated Panels

3. Enclosure. The enclosures considered herein are housings such as consoles, cabinets, and cases, which are designed to provide protection and support to mechanisms, parts, and assemblies.

4. Design. Enclosures shall be designed to provide protection for the contained equipment against environmental conditions as specified in the detail equipment specification.

4.1 Enclosures and mounting bases for airborne equipment. Materials, bonding, shielding and performance requirements of MIL-C-172 shall apply to all cases. Mounting bases shall conform to MIL-C-172 or MIL-M-81288, as applicable.

4.2 Enclosures for aerospace ground support equipment. The detailed equipment specification or contract for the particular equipment will specify the type of case to be supplied by the contractor. Transit cases and combination type cases may not be required for ship, depot, or field shops wherever the area of use is protected or controlled for human occupancy.

4.3 Degree of enclosure. Unless otherwise specified in the detail equipment specification, enclosures shall be designed in accordance with MIL-STD-108, table 1 for the degree of enclosure best suited to the application. Where moisture buildup in sealed equipment cannot be tolerated, the use of desiccants or dehydrating agents should be considered. Moisture absorbent materials such as open-celled foam shall not be used to fill moisture pockets.

4.4 Materials. Enclosures shall be constructed of either a corrosion-resistant material or a material which has been protected against corrosion. The material used for enclosures shall be the lightest practical, consistent with the strength required for sturdiness, serviceability and safety.

4.5 Racks and panels. Where applicable in the design of enclosures and supports, the internal clearance and the equipment mounting holes of racks and panels shall be in accordance with MIL-STD-189.

5. Test requirements. Unless otherwise specified, the enclosure shall be tested as specified in MIL-STD-108.

REQUIREMENT 56

ROTARY SERVO DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of rotary servo devices such as servomotors, synchros, resolvers, tachometer generators, encoders, and transolvers.

2. Documents applicable to Requirement 56:

MIL-S-22432	Servomotors, General Specification
MIL-S-22820	Servomotor-Tachometer Generator AC, General Specification for
MIL-T-22821	Tachometer Generator AC, General Specification for
MIL-R-50781	Resolver, Electrical, Linear, General Specification for
MIL-E-81512	Encoder, Shaft Position to Digital, Contact Type, Altitude Reporting, General Specification for
MIL-S-81963	Servo Components, Precision Instrument, Rotating, Common Requirements and Tests, General Specification for
MIL-T-83727	Transolvers, General Specification for
MIL-E-85082	Encoders, Shaft Angle to Digital, General Specification for
MIL-STD-710	Synchros, 60 and 400 Cycle
MIL-STD-1451	Resolvers, Electrical, Selection of
MIL-HDBK-214	Synchros
MIL-HDBK-218	Application of Electrical Resolvers
MIL-HDBK-225	Synchros, Description and Operation
MIL-HDBK-231	Encoder, Shaft Angle to Digital

3. Rotary servo devices. Rotary servo devices shall conform to MIL-S-81963 as applicable.

4. Servomotors. Servomotors shall conform to MIL-S-22432 or MIL-S-22820 when the motor is coupled to a tachometer generator.

5. Synchros. Synchros shall be selected and applied in accordance with MIL-STD-710. MIL-HDBK-225 may be used as a guide for application.

6. Synchro reference data. For technical reference data on standard synchro types for new design and on synchros required for maintenance of existing equipment, refer to MIL-HDBK-214.

7. Resolvers. Resolvers shall be selected and applied in accordance with MIL-STD-1451. MIL-HDBK-218 may be used as a guide for application.

7.1 Linear resolvers. Linear resolvers shall conform to MIL-R-50781.

8. Tachometer generators. Tachometer generators shall conform to MIL-T-22821 or to MIL-T-22820 when the tachometer generator is coupled to a servomotor.

9. Transolvers. Transolvers shall conform to MIL-T-83727.

10. Encoders. Encoders shall conform to MIL-E-85082 for general application. For altitude reporting applications, encoders shall conform to MIL-E-81512. MIL-HDBK-231 may be used as a guide for application.

REQUIREMENT 57

RELAYS

1. Purpose. This requirement establishes criteria for the selection and application of relays.

2. Documents applicable to Requirement 57:

MIL-R-28750	Relay, Solid State, General Specification for
MIL-STD-1346	Relays, Selection and Application

3. Selection and application. Relays shall be selected and applied in accordance with MIL-STD-1346 and the following:

3.1 Solid state relays. Solid state relays shall be selected from MIL-STD-1346 or shall conform to MIL-R-28750.

3.2 Load transfer relays. Relays which are not designed specifically for load transfer applications shall not be used for this purpose.

3.3 Reed relays. The selection and application of reed relays in airborne applications require procuring activity approval.

REQUIREMENT 58

SWITCHES

1. Purpose. This requirement establishes criteria for the selection and application of switches and associated hardware (including boots and panel seals). This requirement is not applicable to RF coaxial switches.

2. Documents applicable to Requirement 58:

MIL-S-12285	Switch, Thermostatic
MIL-S-15743	Switches, Rotary, Enclosed
MIL-S-18396	Switches, Meter and Control, Naval Shipboard
MIL-S-21604	Switches, Rotary, Multipole and Selector Type, 1 to 10 Ampere
MIL-S-83731	Switch, Toggle, Unsealed and Sealed Toggle, General Specification for
MIL-STD-1132	Switches and Associated Hardware, Selection and Use of

3. Selection and application. Switches and associated hardware shall be selected and applied in accordance with MIL-STD-1132. Switches required other than those listed in MIL-STD-1132 shall conform to one of the following specifications: MIL-S-12285, MIL-S-15743, MIL-S-18396, MIL-S-21604, MIL-S-83731.

3.1 Detent action. Switches shall have a detent action to indicate activation, except for those with momentary positions or with an increase-decrease function, or those which are nonmanually operated.

3.2 Slide switches. Slide switches shall not be used without prior approval of the procuring activity.

REQUIREMENT 59

BRAZING

1. Purpose. This requirement establishes criteria for brazing.

2. Document applicable to Requirement 59:

MIL-B-7883 Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys

3. Brazing. Brazing of steel, copper, copper alloys, nickel alloys, aluminum, and aluminum alloys shall be in accordance with MIL-B-7883.

4. Improved methods and materials. Improved (state-of-the art) methods and materials may be used provided they equal or exceed the requirements of MIL-B-7883, and provided approval is obtained from the procuring activity.

5. Brazing electrical connections. Electrical connections of stranded wire, insulated wire, or having construction which may entrap fluxes, shall not be brazed unless approval is obtained from the procuring activity.

REQUIREMENT 60

SOCKETS AND ACCESSORIES

1. Purpose. This requirement establishes criteria for the selection and application of sockets and accessories for plug-in parts.

2. Documents applicable to Requirement 60:

MIL-S-12883	Socket and Accessories for Plug-In Electronic Components, General Specification for
MIL-S-24251	Shield, Retainer (Bases), and Adapters, Electron Tube, Heat Dissipating, General Specification for
MIL-M-38527	Mounting Pads and Insulator Disks, Electrical-Electronic Component, General Specification for
MIL-S-83734	Sockets, Plug-in Electronic Component, General Specification for

3. Sockets. Sockets for plug-in electronic parts shall be of the single unit type and shall conform to MIL-S-12883 or MIL-S-83734. The use of integrated circuit sockets requires approval of the procuring activity.

4. Shields

4.1 Heat dissipating. Where heat dissipating tube shields are required, they shall conform to MIL-S-24251. Shield bases, used with heat dissipating shields, shall be mounted on clean and smooth metallic mating surfaces to minimize the contact resistance (thermal and electrical) between the base and the supporting chassis.

4.2 Magnetic shielding. Magnetically sensitive devices shall be shielded to minimize the effects of strong magnetic fields. Such devices shall be adequately shielded to assure that their performance shall not be degraded beyond equipment specification limits by a magnetic field external to the equipment, representative of the specified operating environmental conditions.

5. Clamps. Plug-in parts shall be securely retained in their sockets in their proper position under specified service conditions of shock and vibration. A positive holding device, capable of being easily released to allow replacement of the plug-in part, shall be provided where necessary to meet the foregoing environmental requirement.

6. Mounting pads and insulator disks. Where mounting pads and insulator disks are required for use with small electrical or electronic devices, they shall conform to MIL-M-38527.

REQUIREMENT 61

ELECTROMAGNETIC INTERFERENCE CONTROL

1. Purpose. This requirement establishes criteria for electromagnetic interference control.

* 2. Documents applicable to Requirement 61:

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic
MIL-HDBK-253	Guidance for the Design and Test of Systems Protected Against the Effects of Electromagnetic Energy

National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management

3. Requirements. Electromagnetic interference requirements shall be as specified in MIL-STD-461.

3.1 Radar systems and equipment shall also conform to the provisions of MIL-STD-469 and section 5.3 of the National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management (NTIA Manual) as specified in the contract. In the event of conflict, the following descending order of precedence shall prevail: NTIA Manual, MIL-STD-469, MIL-STD-461.

3.2 Tests and test methods shall be as specified in MIL-STD-462. For radar equipments and systems, MIL-STD-469 shall apply.

3.3 MIL-HDBK-253 provides guidance for the design and test of electronic systems which are to be immune to the detrimental effects of electromagnetic energy.

REQUIREMENT 62

HUMAN ENGINEERING

* 1. Purpose. This requirement offers direction as to human engineering requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Human engineering requirements and related test and evaluation requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents applicable to Requirement 62:

MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

* 3. Human engineering requirements. Human engineering applied during development and acquisition of military systems, equipment, and facilities serves to achieve the effective integration of personnel into the design of the system. The objective of a human engineering effort is to develop or improve the crew/equipment/software interface and to achieve required effectiveness of human performance during system operation, maintenance and control and to make economical demands upon personnel resources, skills, training, and costs. MIL-H-46855 is the overall requirements document for the area. It must be tailored when applied; application guidance is offered in the document. MIL-STD-1472 provides design criteria which may be selectively applied as requirements or guidance.

REQUIREMENT 63

SPECIAL TOOLS

1. Purpose. This requirement establishes criteria for the selection and application of special tools.

2. Definition. Special tools (including jigs, fixtures, stands, and templates) are those not listed in the Federal Supply Catalog.

3. Use and authorization. The design of equipment shall be such that the need for special tools for tuning, adjustment, maintenance, replacement, and installation shall be kept to a minimum. Only when the required function cannot be provided by an existing standard tool shall special tools be considered. Necessary tools shall be identified as early as possible. The use of any special tool shall be subject to the approval of the procuring activity.

4. Furnishing and stowing. Special tools needed for operation and organization level maintenance shall be furnished by the contractor and shall be mounted securely in each equipment in a convenient and accessible place, or in a central accessible location for an equipment array requiring such tools.

5. Tool life. Special tools shall be capable of performing the required functions throughout the life of the equipment they support.

REQUIREMENT 64

MICROELECTRONIC DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of microelectronic devices. This requirement is applicable to monolithic, hybrid, and multichip microcircuits, and microcircuit modules.

2. Documents applicable to Requirement 64:

MIL-M-38510	Microcircuits, General Specification for
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1562	Lists of Standard Microcircuits
MIL-HDBK-217	Reliability Stress and Failure Rate Data for Electronic Equipment

3. General. Use of microelectronic technology shall be considered in the design of all systems/equipment and maximum use shall be made of standard microelectronic devices.

4. Selection. Microelectronic devices shall conform to MIL-M-38510, product assurance level class B, as a minimum. Class S is the highest product assurance level of MIL-M-38510 and is intended for space applications or other applications requiring the product assurance provisions of class S. Unless otherwise specified, the order or preference shall be as follows:

a. MIL-M-38510 JAN microcircuits listed in MIL-STD-1562.

b. Other MIL-M-38510 JAN microcircuits, subject to procuring activity approval.

c. DESC Selected Item Drawing microcircuits, subject to procuring activity approval.

d. Other microcircuits (see 4.1), subject to procuring activity approval.

4.1 Non-JAN devices. For other than JAN devices, the following information shall be included in the nonstandard part approval request:

a. Device nomenclature, marking, configuration, functional requirements, parameters and limits sufficient to insure the required form, functions and interchangeability.

b. Required environmental, endurance (life) and other design capability tests.

c. Quality assurance requirements, including screening and lot quality conformance (acceptance) tests. As a minimum, all devices shall be required to pass the MIL-STD-883 class B requirements of screening in accordance with method 5004 and 5008, as applicable, and group A and B lot quality conformance in accordance with method 5005 and 5008, as applicable, and shall have at least initial verification of the group C and D requirements of method 5005 or 5008, as applicable.

* 4.2 Programmable read only memories (PROM). PROM devices, regardless of type, selected for Naval Air System Command use, require approval of the procuring activity.

5. Packages. Microcircuit devices used in equipment shall be hermetically sealed in glass, metal or ceramic (or combinations of these) packages. No organic or polymeric materials such as lacquers, varnishes, coatings, adhesives, or greases shall be used inside the microcircuit package, and no desiccants shall be contained in the microcircuit package unless otherwise specified. No plastic (organic or polymeric) encapsulated or sealed devices shall be used without the approval of the procuring activity.

6. Reliability prediction. When required, reliability predictions for system/equipment design using microcircuit devices shall be prepared in accordance with MIL-HDBK-217.

7. Electrostatic sensitive parts. Certain types of integrated circuits are susceptible to electrostatic discharge damage. Appropriate discharge procedures shall be observed when handling, storing or testing these parts and design selections of desired devices should include a consideration of the effectiveness of the input or other protective elements included in the device design.

REQUIREMENT 65

CABLE, COAXIAL (RF)

1. Purpose. This requirement establishes criteria for the selection and application of coaxial radio frequency (rf) cable.

2. Documents applicable to Requirement 65:

MIL-C-17	Cable, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-L-3890	Lines, Radio Frequency Transmission (Coaxial, Air Dielectric)
MIL-C-22931	Cable, Radio Frequency, Semirigid, Coaxial, Semi-Air Dielectric, General Specification for
MIL-C-23806	Cable, Radio Frequency, Coaxial, Semirigid, Foam Dielectric, General Specification for
MIL-HDBK-216	RF Transmission Lines and Fittings

3. General requirements

3.1 Cable shall be selected from the types and classes specified by the documents listed herein wherever applicable. Other types of cable may be used provided they are selected from specifications acceptable for the specific application and approved by the procuring activity.

3.2 For critical rf circuits, in addition to the electrical characteristics such as VSWR and capacitance, elements such as environmental requirements, short leads, and grounding shall be considered in design applications.

3.3 MIL-HDBK-216 may be used as a technical information guide to applications of transmission lines and fittings.

4. Detail requirements

4.1 Selection of coaxial cable shall be in accordance with MIL-C-17, MIL-L-3890, MIL-C-22931 or MIL-C-23806 unless otherwise specified in the detail equipment specification.

4.2 Polyvinyl chloride insulation. Cable with polyvinyl chloride insulation shall not be used in manned aerospace applications.

REQUIREMENT 66

CABLE, MULTICONDUCTOR

1. Purpose. This requirement establishes criteria for selection and application of electrical multiconductor cable for use within electronic equipment.

2. Documents applicable to Requirement 66:

QQ-W-343	Wire, Electrical (Uninsulated)
QQ-W-423	Wire, Steel, Corrosion-Resisting
MIL-C-17	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-C-442	Cable (Wire), Two Conductor, Parallel
MIL-C-915	Cable and Cord, Electrical, for Shipboard Use, General Specification for
MIL-C-3432	Cable and Wire, Electrical (Power and Control; Semi-flexible, Flexible, and Extra Flexible, 300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, High Temperature
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-C-21609	Cable, Electrical, Shielded, 600 Volt (for Nonflexing Service)
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Electrical, Shielded Pairs
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-55021	Cable, Twisted Pairs and Triples, Internal Hookup, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
ASTM B33-74	Tinned Soft or Annealed Copper Wire for Electrical Purposes

3. General requirements

3.1 Selection. Multiconductor cable shall be selected from the types and classes specified by the documents listed herein wherever applicable. Other types of cable may be used provided they are selected from specifications acceptable for the specific application and approved by the procuring activity.

Table 66-I. Cable, Multiconductor

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexibility at -40°C or -55°C	None			Vinyl-Polymer or synthetic (styrene butadiene) rubber or natural rubber		Lead wire for firing explosive charges
MIL-C-3432	Cable and Wire, Electrical (Power and Control; Semi-flexible, Flexible, & Extra-flexible, 300 and 600 Volts)	QQ-W-343 & Insulation	Unlimited and mixed sizes 4/ 5/	300 & 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene or chloroprene rubber	Extruded & vulcanized	
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for	M-5086/1, /2 and /3	2-7	600	105°C	None			None		
			1-7			Copper	Tin		None		
			1-7			Copper	Tin		Polyamide (nylon)	Extruded or ImpregBraid	
		M22759/12 and /23	1-7		260°C	Copper	Nickel	85	(a)	Extruded	(a) Fluorinated ethylene-propylene
			1-7		260°C	NSA	Nickel	85	(b)	Extruded or tape	(b) Polytetra-fluoroethy-lene
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	
		M81381/8, /10 and /14	2-7		200°C	None			None		
			1-7		200°C	Copper	Nickel	85	FEP/polyimide	Film tape	
		M81381/11, /12 and /13	2-7		200°C	None			None		
			1-7		150°C	Copper	Tin	85	FEP/polyimide	Film tape	
			1-7		200°C	Copper	Nickel	85			
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for	MIL-C-17 QQ-W-343 QQ-W-423 & Insulation	2-78 6/	600	-53°C to +71°C	Copper	Tin	80	Sheath - Polychloroprene	Extruded & vulcanized	See Note 7/
									Primary insulation polyethylene	Extruded	
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use	ASTM B33-74 &Insulation	Multiple twisted pairs 6 pairs-100 pairs	600	75°C	Corrugated Aluminum		100	Polyethylene	Extruded	For use as telephone & telegraph signal cables in shore communication
MIL-C-21609	Cable, Electrical, Shielded, 600 Volt (for Non-flexing Service)	MIL-C-17 MIL-C-915 MIL-W-5086	2-61	600	105°C	Electrolytic tough pitch copper tape	Annealed tape tinned	Not specified	Black polyamide over black PVC		

Table 66-I (Continued)

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-23437	Cable, Electrical, Shielded Pairs	MIL-W-16878/1	Shielded & jacketed twisted pairs 1 pair-104 pairs	600	105°C	Copper	Tin	90	PVC	Extruded	For use within shore communications stations, not to be used on board ship
						Note: Shield applied over each pair					
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor	MIL-C-17	2-36	Var	Not spec	Copper	Tin, Silver	85	Sheath of PVC, polyethylene, polychloroprene, or FEP-Teflon		(a) Flexible multi-conductor cable for use in protected areas: tunnels, wire ways, instrument racks, & conduits. (b) Polyethylene-jacketed cable suitable for underwater or direct burial applications only
		MIL-W-5845		Var	Not spec						
		MIL-W-5846		Var	Not spec						
		MIL-W-5908		Var	Not spec						
		W-16878/1		600	105°C						
		W-16878/2		1000	105°C						
		W-16878/3		3000	105°C						
		W-16878/4		600	200°C						
		W-16878/5		1000	200°C						
		W-16878/10		600	75°C						
						Note: MIL-C-27072 applicable detail specification sheets control materials for each specific cable configuration.					
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace	MIL-W-8777	1-7	600	200°C	Various	Various	85	Various	Braided	For general aerospace flight vehicle applications
		MIL-W-22759	1-7	Var	Var	Various	Various	85	Various	Extruded or braided	
		MIL-W-25038	1-7	600	260°C	Various	Various	85	TFE coated glass fiber	Braided	
		MIL-W-81044	1-7	600	150°C	Various	Various	85	Various	Extruded	
		MIL-W-81381	1-7	600	Var	Various	Various	85	Various	Tape	
MIL-C-55021	Cable, Twisted Pairs and Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000	-40°C to +80°C or -65°C to 200°C	None or Copper	Tin, Silver or Nickel	90	None, PVC, Nylon TFE-Teflon	Extruded Extruded or tape	

NOTES: 1/ Polyester - Polyethylene terephthalate
TFE-Teflon - Polytetrafluoroethylene
PVC - Polyvinyl chloride (Not to be used in airborne applications)
KEL-F - Polymonochlorotrifluoroethylene
FEP-Teflon - Fluorinated ethylene propylene
PVF - Polyvinylidene fluoride

2/ See applicable detail specification sheet for temperature limitation

3/ See applicable detail specification sheet for materials control of specific cable configurations

4/ Although the specification does not limit the number of conductors in a cable, the size, weight, and flexibility are determining factors.

5/ Available in three classifications:

Class L - Light Duty - to withstand severe flexing and frequent manipulation

Class M - Medium Duty - to withstand severe flexing and mechanical abuse

Class H - Heavy Duty - to withstand severe flexing and mechanical abuse and ability to withstand severe service impacts such as to be run over by tanks or trucks.

6/ See applicable detail specification sheet for mechanical test requirements for cold bend, cold bend torque, impact bend, and twist

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

3.2 Characteristics

3.2.1 Solid or stranded. Either solid or stranded conductors may be used (within the restrictions of the particular wire or cable specification) except that (a) only stranded wire shall be used in aerospace applications, and (b) for other applications stranded wire shall be used when so indicated by the equipment application. Specifically, with the exception of flat multiconductor flexible cable, stranded wire shall be used for wires and cables which are normally flexed in use and servicing of the equipment, such as cables attached to the movable half of detachable connectors.

3.2.2 Size. Conductors shall be of such cross section, temper, and flexibility as to provide ample and safe current-carrying capacity and strength. In general, wire shall not be smaller than size 22. Smaller wire may be used when benefits can be obtained with no loss in performance. Specifically, smaller wire may be used in cables having larger numbers of wires and adequate support against vibration. Smaller size wire may be used when necessary for welding of electronic interconnections.

4. Detail requirements

4.1 Selection and application of multiconductor cable shall be in accordance with table 66-I unless otherwise specified in detail equipment specification.

4.2 Application restrictions.

4.2.1 MIL-W-16878 shall not be used for Air Force airborne equipment.

4.2.2 Cables with polyvinyl chloride insulation shall not be used in manned aerospace applications.

REQUIREMENT 67

MARKING

1. Purpose. This requirement establishes criteria for external and internal markings on equipment. Marking for safety, shipping, and handling is not within the scope of this requirement.

2. Documents applicable to Requirement 67:

L-S-300	Sheeting and Tape, Reflecting, Nonexposed Lens, Adhesive Backing
MIL-P-15024	Plate, Tags and Bands for Identification of Equipment
MIL-S-81963	Servo-Components, Precision Instrument, Rotating, Common Requirements and Tests, General Specification for
MIL-STD-12	Abbreviations for Use on Drawings, Specifications, Standards, and In Technical Documents
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-155	Joint Photographic Type Designation System
MIL-STD-195	Marking of Connections for Electrical Assemblies
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-411	Aircrew Station Signals
MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-1285	Marking of Electrical and Electronic Parts
IEEE 200-1975	Reference Designations for Electrical and Electronic Parts and Equipments

3. General requirements for marking

3.1 General. Permanency and legibility, size, durability, location, and lettering of marking shall be in accordance with the applicable specification or standard specified herein, or as specified by the procuring activity.

3.2 Patent information. At the manufacturer's option, patent information may be included on equipment, subject to the following restrictions:

a. The identification plate may contain patent information when approved by the procuring activity.

b. The location of and method used to mark patent information shall not conflict with any specified equipment requirements, such as marking, enclosure integrity, control and indicator locations, etc.

c. Patent information shall not be located on or in equipment having a security classification of confidential or higher, with the exception that patented items used in security classified equipment, when marked, shall be marked in such a manner that patent information will be visible only when the item is removed or disassembled for repair or replacement.

4. Items and parts requiring markings or identification

4.1 Type designated items. Each item which is type designated in accordance with MIL-STD-196 or MIL-STD-155 shall contain an identification marking in accordance with MIL-STD-130. These items are systems (electrical-electronic), sets, groups, and some units and assemblies, as defined in MIL-STD-280.

4.1.1 Identification plates. Identification plates shall be in accordance with MIL-P-15024. Items which are impractical to mark with an identification plate shall have the markings applied directly to the item.

4.1.2 Information plates. Information plates, provided to indicate wiring and schematic diagrams, calibration charts, operating instructions, and similar information, shall be in accordance with MIL-P-15024.

4.2 Fuse holders. The current rating of fuses shall be permanently marked adjacent to the fuse holder. In addition, "SPARE" shall be marked adjacent to each spare fuse holder.

4.3 Terminal boards, strips and blocks. All terminals, terminal boards, strips and blocks shall be marked in a clear and permanent manner so as to identify individual terminals.

4.4 Connections. Marking adjacent to plugs, jacks and other electrical connectors shall identify the connected circuits to preclude cross connections. The connections to electrical parts such as motors, generators and transformers shall be marked in accordance with MIL-STD-195.

4.5 Servo components connections and markings. Servo component marking and connection identification shall conform to MIL-S-81963.

4.6 Controls and indicating devices. Markings shall be provided on the front of each exterior and interior panel and panel door, also on control mounting surfaces of each chassis, subpanel, etc, to clearly (though necessarily briefly) designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding through, or available through access holes therein. All markings shall be located on the panel or chassis in correct relationship to the respective designated items.

4.7 Sockets. The chassis shall be marked to identify both sockets and parts, modules, or assemblies to be plugged into the sockets. The side of the chassis upon which items are plugged into sockets shall be marked, adjacent to each socket, with the reference designation for the item. The reverse side of the chassis shall be marked, adjacent to each socket, with the reference designation used in the circuit diagram and table of parts to identify the socket itself. If space does not permit marking of reference designations for sockets and parts, modules, or assemblies mounted in sockets, a location diagram shall be placed where it is visible when viewing the chassis, and shall display the markings described herein.

4.8 Cables, cords and wires. All cables, cords and wires which require disconnection to remove units for servicing and maintenance shall be uniquely identified.

4.9 Printed wiring boards. Markings on printed wiring boards shall not interfere with electrical operation. When ink is used, it shall be non-conductive. Markings shall be considered when leakage (creepage) distances are determined.

4.10 Replaceable parts and assemblies. Replaceable parts and assemblies shall be marked for identification in accordance with MIL-STD-1285 or MIL-STD-130, as applicable.

4.11 Cable assemblies. Cable assemblies which have a type designation shall be marked with the information required for identification plates used on assemblies. See 4.1.

4.12 Modules. Replaceable modules shall be marked with the following data (listed in order of decreasing precedence as space permits): identifying number, terminal identification, ratings, and wiring diagram, as applicable.

5. Symbology

5.1 Reference designations. Except for external connectors and cables, reference designations shall be employed to identify the location of each item for its particular circuit application. The identification and marking of reference designators for parts and equipment shall be in accordance with IEEE 200. On subminiaturized assemblies, such as printed or etched boards or other forms of assembly where space is at a premium, the reference designations need not be marked. In lieu thereof, reference designation marking shall be shown by means of pictorial diagrams, line drawings, photographs, or other media to provide for circuit identification (by means of reference designations) in the appropriate handbooks for the equipment. It shall not be mandatory to mark the reference designations of parts in nonrepairable subassemblies. Connectors may be further identified on that side of the panel to which the mating connector attaches, by a name denoting the function of the cable attached thereto. External cables shall be assigned reference designations W1, W2, etc, in accordance with IEEE 200. The numerical portions of the reference designations shall be consecutive, where practicable.

5.2 Abbreviations and legends. Abbreviations and legends shall conform to MIL-STD-12, MIL-STD-411, or MIL-STD-783, as applicable.

6. Marking methods

6.1 Direct marking. Markings applied directly to a part or an assembly shall be affixed only by die or rubber stamping, etching, engraving, molding, casting, forging, decalcomania transfer, stenciling, or silk screening. Nonepoxy ink markings shall be protected by a clear transparent epoxy coating.

6.2 Plates. Information and identification plates shall be marked in accordance with the methods specified in MIL-P-15024.

6.2.1 Identification (ID) plates. When no method of mounting is specified, the ID plate shall be fastened in such a manner as to remain firmly affixed throughout the normal life expectancy of the item to which it is attached. Hermetically sealed items, magnesium cases, or other items where mounting of a plate by mechanical fasteners is impractical, shall have type G, adhesive-backed metal, ID plates.

6.2.2 ID plates location. ID plates shall be located in a conspicuous place on the equipment so that they may be easily seen and read. Whenever practicable, plates shall be situated so that other parts or portions of the equipment will not obscure their view when in the final assembled position.

6.3 Marking cables, cords and wires. The following methods may be used to mark cables, cords and wires:

a. Molded on the cable or cord.

b. Stamped on the cable, cord or wire.

c. Non-metallic bands such as sleeves, heat shrinkable sleeves or plastic bands securely attached or captivated so that they cannot slip off.

d. Adhesive tag or tape that will withstand the applicable environmental requirements.

6.3.1 Reflective markers. Where cable markers are required for night or blackout conditions, pre-printed reflective tape markers may be used. The reflective polyester tape shall be in accordance with L-S-300 and non-epoxy ink markings shall be overcoated with clear, compatible epoxy.

REQUIREMENT 68

READOUTS, INCANDESCENT

1. Purpose. This requirement establishes criteria for the selection of readouts.

2. Documents applicable to Requirement 68:

MIL-R-28803 Readouts, Segmented, General Specification for

3. Definition. Readouts are devices which are designed primarily to convert electrical information into alphanumeric or symbolic displays.

4. Incandescent type. Incandescent type readouts shall conform to MIL-R-28803.

REQUIREMENT 69

INTERNAL WIRING PRACTICES

1. Purpose. This requirement establishes criteria for internal wiring practices.

2. Documents applicable to Requirement 69:

MIL-T-152	Treatment, Moisture and Fungus Resistant, of Communications, Electronic and Associated Electrical Equipment
MIL-V-173	Varnish, Moisture Resistant (For Treatment of Communications, Electronic, and Associated Equipment)
MIL-I-631	Insulation, Electrical, Synthetic - Resin Composition, Non-Rigid
MIL-T-713	Twine: Impregnated, Lacing and Tying
MIL-I-3158	Insulation Tape, Electrical Glass-Fiber (Resin Filled); and Cord, Fibrous-Glass
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-T-7928	Terminals, Lug and Splice, Crimp Style, Copper
MIL-I-18057	Insulation Sleeving, Electrical, Flexible Glass Fiber, Silicone Rubber Treated
MIL-I-22076	Insulation Tubing, Electrical, Non-Rigid, Vinyl, Very Low Temperature Grade
MIL-I-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
MIL-S-23190	Strap, Clamps, and Mounting Hardware, Plastic, For Cable Harness Tying and Support
MIL-T-43435	Tape, Lacing and Tying
MIL-C-55543	Cable, Electrical, Flat Multiconductor, Flexible, Unshielded
MIL-STD-108	Definition of and Basic Requirements for Enclosure for Electric and Electronic Equipment
MIL-STD-1130	Connections, Electrical, Solderless, Wrapped

3. Clearance and leakage (creepage) distances. Clearance between solder connections or bare conductors, such as on terminal strips, stand offs or similar connections, shall be such that no accidental contact can occur between adjacent connections when subjected to service conditions specified in the equipment specification. For electrical clearance and leakage distances, see table 69-I.

4. Impedance matching. Where rf cables are employed, equipment shall be designed to attain proper impedance matching with the cable and fittings.

5. Wiring protection. The wiring shall be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers). For securing of wiring, polyamide clamps or wrapping and tying devices with integral mounting facilities are preferred. Metal clamps, if used, shall be insulated. Individual conductors thus secured shall lie essentially parallel; however, this does not prohibit the use of twisted pairs.

Table 69-I. Electrical Clearance and Leakage (Creepage) Distances

Voltage ac (rms) or dc	Condition	Clearance (Inches)	Leakage Distances (inches)	
			Enclosure I	Enclosure II
To 150	A	1/16	1/16	1/16
	B	1/8	1/8	1/4
	C	1/4	3/8	3/4
150-300	A	1/16	1/16	1/16
	B	1/8	1/8	1/4
	C	1/4	1/2	3/4
300-600	A	1/16	1/8	1/8
	B	1/8	1/4	1/4
	C	1/4	1/2	3/4
600-1000	A	1/8	3/8	1/2
	B	1/4	3/4	1
	C	1/2	1-1/2	2

Condition A. For use where the effect of a short circuit is limited to the unit, and where normal operating power does not exceed 50 watts.

Condition B. For use where short circuit protection in the form of fuses, circuit breakers, etc, is provided, and where normal operating power does not exceed 2000 watts.

Condition C. For use where short circuit protection in the form of fuses, circuit breakers, etc, is provided, and where normal operating power exceeds 2000 watts.

Enclosure I. Enclosure I is an equipment enclosure which has no openings, or in which the openings are so constructed that drops of liquid or solid particles striking the enclosure at any angle from 0o to 15o from the downward vertical cannot enter the enclosure either directly or by striking and running along a horizontal or inwardly inclined surface. ("Drip-proof enclosure for other than motors, generators, and similar machines" of MIL-STD-108 meets this description.)

Enclosure II. Enclosure II is any equipment enclosure which affords less protection than enclosure I.

5.1 Insulation cold flow. Where insulated wire that may be susceptible to cold flow is used, care shall be exercised so that there will be no cold flow of the insulation.

5.2 Cable ducts. Where cable ducts are employed, provisions shall be made for the removal of any wire that may become faulty. For example, covers may be employed at intervals to aid in the removal of a faulty wire.

5.3 Bend radius. The bend radius of polyethylene cable shall not be less than five times the cable diameter to avoid establishing a permanent set in the cable.

5.4 Sleeving. Flexible plastic sleeving, either nonflammable, self extinguishing, or flame retardant, shall be used on cables subject to flexing, such as panel door cables. The sleeving shall be secured under cable clamps at each end, and the cable shall be formed and secured so that the cable will not be subject to abrasion in its normal flexing motion. In cases where abrasion cannot be avoided, additional protection shall be provided.

5.5 Panel door cables. Wiring to parts on a hinged door shall be in a single cable, arranged to flex without being damaged when the door is opened and closed. However, if physical separation between wires is essential for electrical reasons, or if the number of wires involved is so great as to make a single cable impracticable, more than one flexible hinging cable may be employed.

5.6 Through hole protection. Whenever wires are run through holes in metal partitions, shields, and the like, less than 1/8 inch in thickness, the holes shall be equipped with suitable mechanical protection (grommet) of insulation. Panels 1/8 inch or more in thickness either shall have grommets or shall have the hole edges rounded to a minimum radius of 1/16 inch. Grommets for wires operating at rf potentials exceeding 500 volts rms, shall be of ceramic or plastic material of suitable dielectric strength, except for coaxial cables which have outside protection, where rubber or neoprene is acceptable. Insulating grommets are not required for wires or groups of wires passing through shields or other metallic partitions where clearance can be maintained sufficient to preclude the possibility of accidental contact or damage by abrasion.

6. Electrical tape. Only electrical tape made of fungus-inert materials may be used.

7. Wiring

7.1 Wiring arrangement. All wiring shall be arranged in a neat and workmanlike manner. The use of preformed cables and wiring harness is preferred to the point-to-point method of wiring. Wires shall be bundled and routed to minimize electrical coupling. Where practicable, sensitive circuits in a wire bundle or cable shall not be placed adjacent to a disturbing circuit. Materials used for lacing, binding, sleeving, and strapping shall be compatible with the conductor or cable insulation or jacket and shall meet the same flame retardant and self extinguishing requirements. Wiring shall be arranged to permit bundling by one or more of the following methods or permanently mounted in cable ducts.

7.1.1 Lacing. Twine shall be in accordance with type P of MIL-T-713. Type SAR shall not be used where it may be exposed to fungus attack. Tape shall conform to MIL-T-43435. Cordage shall be in accordance with type SR-4.5 of MIL-I-3158.

7.1.2 Binding. Tape for binding shall be as specified in MIL-T-43435.

7.1.3 Sleeving insulation. Sleeving insulation shall conform to MIL-I-631, MIL-I-3190, MIL-I-18057, MIL-I-22076 or MIL-I-23053, as applicable.

7.1.4 Wrapping and tying. Plastic devices for wrapping and tying of wires may be provided so that the material does not support combustion, nor yield toxic gases when heated. When the wire bundle is formed and secured, the device shall not loosen when subjected to vibration. Plastic cable straps shall conform to MIL-S-23190.

7.1.5 Tape selection. Minimum tape size shall be in accordance with table 69-II. Tape dimensions shown are nominal and are subject to the tolerances of MIL-T-43435.

Table 69-II. Minimum Tape Size

Harness diameter (inches)	Tape size (width in inches)
Up to 1/2	.050
1/2 to 1	.085
1 to 2	.110
2 and larger	.200

7.2 Slack. Wires and cable shall be as short as practicable, except that sufficient slack shall be provided to:

a. Prevent undue stress on cable forms, wires and connections, including connections to resiliently support parts.

b. Enable parts to be removed and replaced during servicing without disconnecting other parts.

c. Facilitate field repair of broken or cut wires.

d. Permit units in drawers and slide out racks to be pulled out to the limit of the slide or support travel without breaking connections. Units which are difficult to connect when mounted, shall be capable of movement to a more convenient position for connecting and disconnecting cables. When drawers or racks are fully extended and rotated, if rotatable, the cable bend radius shall not be less than three times the cable assembly diameter. When flat molded cable assemblies are used, the bend radius shall not be less than ten times the cable assembly thickness.

e. Permit replacement of at least two of the particular parts to which the wire or cable is connected. The only exceptions to this provision are cases where rf leads must be as short as possible for electrical reasons and when fixed path

rotating is specified or the amount of slack is limited by space available as occurs in automatic machine wired panels.

f. Ensure freedom of motion of lugs or terminals normally intended to have some degree of movement (for example, floating contacts on electron tube sockets).

7.3 Wiring in terminal boxes. Wiring and cables in terminal boxes shall be fanned out to identify terminals for check purposes if test points for required maintenance information are not provided.

7.4 Entrance cabling and wiring. Leads from cable entrances to terminal boards, plugs, jacks, and similar devices shall be harnessed, suitably clamped or supported in a cable duct. Flat cable in accordance with MIL-C-55543 may be used where suitable.

7.5 Wiring (internal). Stranded wire is preferred; however, solid wire may be used in the equipment, provided such wire is so insulated or held in place that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions. An uninterrupted wire is preferable to a junction. The following descending order of preference exists when junctions are used, and the choice of the listed junctions shall be determined by consideration of reliability factors, maintenance factors, and manufacturing procedures:

a. Permanent splices

b. Bolted connections

c. Connectors.

7.6 Connections. Wiring to connections within the equipment shall be suitably supported in such manner as to prevent breakage and eliminate changes in characteristics or output as a result of vibration and acceleration or shock encountered under the specified service conditions.

7.7 Connectors, wired in. Plugs and receptacles furnished as integral wired in parts of articles of equipment shall be processed by providing a means to lengthen leakage distances, to spread the area of flexure of connector wires, and to move the flexure away from the terminals.

7.8 Support. Wire and cable shall be properly supported and secured to prevent undue stress on the conductors and terminals and undue change in position of the wire or cable during and after subjection of the equipment to specified service conditions, or after service or repair of the equipment in a normal manner. When shielding on wire or cable is unprotected by an outer insulation, adequate support is necessary to prevent the shielding from coming in contact with exposed terminals or conductors. Twine or tape shall not be used for securing wire and cable.

7.9 Cable and harness design. Cables and separable harnesses shall be of the two-connector type whenever possible. Also, when possible, the two connectors shall be of the same number of contacts and all contacts shall be wired point-to-point (i.e., pin 1 to pin 1, pin A to pin A, or pin 1 to pin A and up

in sequence). A minimum number of connector types and contact configurations within a type shall be used consistent with non cross mating requirements and circuit and spare considerations.

8. Wire terminations

8.1 Soldering connections. Studs (soldering posts to which parts are permanently affixed), soldering lugs (projections which solder to ends of wires to facilitate attachment to solderless connections), and soldering terminals (items which are attached to the chassis, or insulating boards, strips, or posts to serve as a solder junction for two or more wires or leads) come under this heading. All soldering studs, lugs, and terminals shall be notched or otherwise provided with means for mechanically securing the wire or lead prior to the application of solder. All solder type studs shall be mounted in such manner as to preclude their loosening or rotation due to soldering operations or from strains due to attached wires or leads.

8.2 Mechanical strength. Soft solder alone shall not be depended upon for mechanical strength.

8.3 Solderless crimp connections. The ends of each wire terminated by solderless crimp type lugs shall meet the following requirements:

a. Insulated, solderless contacts are preferred and shall conform to MIL-T-7928.

b. Where thermal or other considerations prevent the use of insulated lugs, noninsulated solderless lugs conforming to MIL-T-7928 shall be used, provided they are covered with an insulating sleeve.

8.4 Solderless wrapped wire connections. Solderless wrapped wire connections shall be in accordance with MIL-STD-1130. Procuring activity approval is required for Navy airborne and Army missile applications.

8.5 RF connections. Whenever bolts, screws, nuts, studs, or rivets are used in an rf circuit, all connections thereto shall be securely soldered, except that soldered connections are not considered practicable at studs of molded phenolic capacitors, meter terminals, and other places where damage from overheating may result.

8.6 Clamped connections. In no case shall electrical connections depend upon wires, lugs, terminals, and the like, clamped between a metallic member and an insulating material of other than a ceramic or vitric nature. Such connections shall be clamped between metal members, preferably, such as an assembly of two nuts, two washers and a machine screw.

9. Connectors, insulation sleeving. Unpotted connectors furnished as integral wired in parts of articles of equipment shall have a piece of insulating tubing placed over each wire in the connector. The tubing shall be long enough to cover the contact and at least 1/2 inch of insulation of the wire attached to it; but in no case shall the length of the tubing exceed 2 inches. The minimum length of 1/2 inch may be reduced to 3/16 inch where restricted volume does not permit longer tubing (such as in miniaturized electronic subassemblies). The

tubing shall fit tightly over the contact or be tied securely enough so that it will not slide off. If bare wire is used, the tubing shall be long enough to extend at least 1/4 inch beyond the contact, metal shell or clamp, whichever projects the farthest. This does not apply to connectors with body insulated crimp-on contacts, nor to wire wrapped connectors in accordance with MIL-STD-1130.

10. Cables, waveguides, and cable assemblies. Except when otherwise specified in the detail equipment specification, all interconnecting cables carrying rf signals shall make use of coaxial cable or waveguides and shall preferably be terminated in the characteristic impedance of the transmitting media. Conductors intended to carry pulse or other waveforms and which may undesirably couple such signals into other conductors shall not be bound into a cable.

11. Fungus protection. Prior to attachment of terminals to prepared lengths of cables which contain materials that will support fungus, the ends shall be protected against entrance of moisture and fungus by treatment with a fungicidal varnish conforming to MIL-V-173 in accordance with MIL-T-152.

REQUIREMENT 70

ELECTRICAL FILTERS

1. Purpose. This requirement establishes criteria for the selection and application of electrical filters.

2. Document applicable to Requirement 70:

MIL-STD-1395 Filters and Networks, Selection and Use of

3. Electrical filters. Electrical filters shall be selected and applied in accordance with MIL-STD-1395.

REQUIREMENT 71

CABLE AND WIRE, INTERCONNECTION

1. Purpose. This requirement establishes criteria for the selection and application of electric cable and wire used for interconnection between units.

2. Documents applicable to Requirement 71:

QQ-W-343	Wire, Electrical (Uninsulated)
QQ-W-423	Wire, Steel, Corrosion-Resisting
MIL-C-17	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-W-76	Wire and Cable, Hookup, Electrical, Insulated
MIL-C-442	Cable, Two Conductor, Parallel
MIL-C-915	Cable and Cord, Electrical, For Shipboard Use, General Specification for
MIL-C-3432	Cable and Wire, Electrical (Power and Control; Flexible and Extra Flexible, 300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-W-7072	Wire, Electric, 600 Volt, Aluminum, Aircraft, General Specification for
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-W-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200oC
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, High Temperature
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-C-21609	Cable, Electrical, Shielded, 600 Volt (for Nonflexing Service)
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Electrical, Shielded Pairs
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, Aircraft
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-55021	Cables, Twisted Pairs and Triples, Internal Hookup, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy

Supersedes
REQUIREMENT 71
30 June 1979

REQUIREMENT 71
15 August 1981

MS25191	Wire, Electric, 600 Volt, Aluminum, Aircraft
MS25471	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200oC, Polyester Jacket
MS27110	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200oC, FEP Jacket
ASTM B33-74	Tinned Soft or Annealed Copper Wire for Electrical Purposes

3. General requirements

3.1 Electrical connections shall be arranged and wired so that no leads are terminated in pins or other exposed contacts which might be accidentally shorted or touched.

3.2 All interconnecting cables carrying pulsed or rf signals shall make use of coaxial cable or waveguides and shall be terminated, when possible, in the characteristic impedance of the transmitting media, except when this requirement conflicts with the detail specification.

3.3 All open-wire power and control cables shall be terminated in the lowest impedance practicable for the particular application.

3.4 The shield of shielded cables shall be connected to a ground lead at least at one point in the circuit.

3.5 Consideration shall be given to weight saving by use of aluminum wires and cables; however, approval for their installation shall be obtained from the procuring activity.

4. Detail requirements

4.1 Selection of wire for interconnection between units shall be in accordance with table 71-I unless otherwise specified in the detail equipment specification.

4.2 Selection of flexible or semi-rigid coaxial cable for interconnection between units shall be in accordance with the applicable coaxial cable requirements.

4.3 Selection of multiconductor cable for interconnection between units shall be in accordance with table 71-II unless otherwise specified in the detail equipment specification.

4.4 Application restrictions

4.4.1 MIL-W-76 shall be used for Army application only.

4.4.2 MIL-W-16878 shall not be used for Air Force airborne equipment.

4.4.3 Cable or wire with polyvinyl chloride insulation shall not be used in manned aerospace applications.

5. Definitions

5.1 Interconnecting wire. Insulated, single-conductor wire used to carry electric current between units. Hook-up wire may be used for this purpose providing adequate jacketing is applied to the wire bundle to render it serviceable in the specified environment.

5.2 Interconnecting cable. Two or more insulated conductors contained in a common covering or one or more insulated conductors with a gross metallic shield or outer conductor used to carry electrical current between units.

Table 71-I. Wire, Electrical, Interconnection

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor: Material	Conductor: Coating	Conductor: Type	2/ Insulation: Primary	Insulation: Primary Cover	Insulation: Jacket	Max Cndct Temp °C	Max rms Volts	Remarks
MIL-W-76	Wire and Cable, Hookup, Electrical Insulated	LW	Cu/A or CCW	Sn	S or Str	1	8,10 or 13A 3/	8,10 or 13A 3/	80	300	a) See Note 4
		MW								1000	b) See Note 5
		HW								2500	c) For Army use only
		HF				2A				1000	
MIL-E-5086	Wire, Electric, PVC Insulated, Copper or Copper Alloy	M5086/1	Cu/A	Sn	Str	1		8	105		
		M5086/2					13A	8 or 11			
		M5086/3								600	
		M5086/4						8		3000	Medium weight
		M5086/5						9A	110	600	
		M5086/6	HSA	Ag							See Note 4
		M5086/7	Cu/A	Sn				8	105	600	
MIL-W-7072	Wire, Electric, 600 Volt, Aluminum, Aircraft	MS25191	Alum		Str	1	13A	11	105	600	
MIL-W-8777	Wire, Electrical, Silicone Insulated, Copper, 600 V 200°C	MS25471	Cu/A	Ag	Str	6	13A	12	200	600	
		MS27110	Cu/A	Ag	Str	6	13A	4A			
MIL-W-16878	Wire, Electrical, Insulated, High Temperature	/1-B	Cu/A	Sn	Str	1	8,10,11	1,8,10,11		600	a) High strength copper alloy conductor allowed in AWG sizes 26 through 32
		/2-C		Sn		1	8,10,11		105	1000	
		/3-D		Sn		1	8,10,11			3000	
		/4-E		Ag		3A,3B		3A,3B,13B 3/	200	600	b) See Note 4
		/4-E		Ni				4A	260		c) See Note 5
		/5-EB		Ag					200	1000	
		/5-EE		Ni					260		
		/6-ET		Ag					200	250	
		/6-ET		Ni					260		
		/7-F		Ag		6	4A,8,10,11	4A,8,10,11		600	
		/8-FF		Ag		6	4A,8,10,11	4A,8,10,11	200	1000	
		/9-FFW		Ag		6	4A,8,10,11	4A,8,10,11		1000	
		/10-J		Sn		2A	8,10,11		75	600	
		/11-K		Ag		4A		4A		600	
		/12-KK		Ag		4A		4A	200	1000	
		/13-KT		Ag		4A		4A		250	
MIL-W-19150	Wire, Insulated, Hard-Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer - Insulated, Copper or Copper Alloy	/1	Cu/A	Ag	Str	3A/3B/3D		13B	200	600	
		/2		Ni		3A/3B/3D		13B	260	600	
		/3		Ni		3B/3D	13B	3B	260	600	
		/4		Ag		3B/3D	13B	4A	200	600	
		/5		Ag		3C			200	600	
		/6		Ni		3C			260	600	
		/7		Ag		3C			200	600	Medium weight
		/8		Ni		3C			260	600	Medium weight
		/9		Ag		3A			200	1000	
		/10		Ni		3A			260	1000	
		/11		Ag		3A			200	600	
		/12		Ni		3A			260	600	
		/13		Sn		4A		9A	135	600	Medium weight
		/14		Sn		4A		9A	135	600	Light weight
		/15	HSA	Ag		4A		9A	135	600	Light weight
		/16	Cu/A	Sn		1B			150	600	Medium weight

Table 71-I (Continued)

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Coating	Type	2/ Insulation Primary	Primary Cover	Jacket	Max Cndct Temp °C	Max rms Volts	Remarks
MIL-W-22759 (Cont'd)	Wire, Electric, Fluoropolymer - Insulated, Copper or Copper Alloy	/17	hSA	Ag	Str	18			150	600	Medium weight
		/18	Cu/A	Sn		18			150	600	Light weight
		/19	HSA	Ag		18			150	600	Light weight
		/20		Ag				3A	200	1000	
		/21		Ni				3A	260	1000	
		/22		Ag				3A	200	600	
		/23		Ni				3A	260	600	
		/28	Cu/A	Ag		3A		7B	200	600	
		/29	Cu/A	Ni		3A		7B	260	600	
		/30	HSA	Ag		3A		7B	200	600	
		/31	HSA	Ni		3A		7B	200	600	
		/32	Cu/A	Sn		20			150		
		/33	HSA	Ag							
		/34	Cu/A	Sn				20			
		/35	HSA	Ag							
		/41	Cu/A	Ni					200		
		/42	HSA	Ni							
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant	M25038/1	Cu/A	Ni clad	Str	15	3B	13B	288	600	Critical circuits where electrical integrity must be maintained during fire (1093°C flame/5 min)
MIL-W-81044	Wire, Electric, Cross-linked Polyalkene, Cross-linked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy	/1	Cu/A	Ag	Str	2B		9B	135	600	Sheets /3, /4, /11, /12, & /13 Light weight
		/2		Sn							
		/3		Ag							Sheets /8, /9, /10, /14, & /15 Medium weight
		/4		Sn					150		
		/5		Ag							a) /4, /12, /13 - See Note 4
		/6		Sn							b) See application temp limitation stipulated on detail specification sheet
		/7	HSA	Ag							
		/8		Ag							
		/9		Sn							
		/10	HSA	Ag							
		/11	Cu/A	Ag							
		/12	Cu/A	Sn							
		/13	HSA	Ag							
		/14	Cu/A	Sn					135		
		/15	HSA	Ag							
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	/1	Cu/A	Ag	Str	7A		4B	200	600	Sheets /1, /2, & /5 through /10 Light weight
		/2	Cu/A	Ni				4B			Sheets 3/, /4, & /11 through /14 Medium weight
		/3	Cu/A	Ag				4B or 3B			Sheets /17 through /20 Light weight, single wrap primary
		/4	Cu/A	Ni				4B or 3B			
		/5	HSA	Ag				4B			a) Interconnect wiring where weight, space, and high-temp capability are critical
		/6	HSA	Ni				4B			b) /7 through /10 & /17 through /20 - See Note 4
		/7	Cu/A	Ag				17			c) 3B jackets in /3, /4, /11, & /12 are in sizes 8 and larger.
		/8	Cu/A	Ni							
		/9	HSA	Ag							
		/10	HSA	Ni							
		/11	Cu/A	Ag				17 or 3B			
		/12	Cu/A	Ni				17 or 3B			
		/13	HSA	Ag				17			
		/14	HSA	Ni							
		/17	Cu/A	Ag							
		/18	Cu/A	Ni							
		/19	HSA	Ag							
		/20	HSA	Ni							
		/21	Cu/A	Sn					150		
		/22	Cu/A	Sn							

Table 71-I (Continued)

NOTES:

1/

Conductor Code		Description
Material	Cu/A	Copper, annealed
	Cu/H	Copper, hard-drawn
	CCW	Copper covered steel
	HSA	High strength copper alloy
	Al	Aluminum
Coating	Sn	Tin
	Ag	Silver
	Ni	Nickel
Type	S	Solid
	Str	Stranded

2/

Insulation Code	Description
1	Polyvinyl chloride/extruded
2A	Polyethylene/extruded
2B	Polyalkene/cross-linked extruded
3A	Polytetrafluoroethylene/extruded (TFE Teflon)
3B	Polytetrafluoroethylene/tape
3C	Polytetrafluoroethylene/mineral filled/extruded
3D	Polytetrafluoroethylene impregnated glass tape
4A	Fluorinated-ethylene propylene/extruded (FEP Teflon)
4B	Fluorinated-ethylene propylene/dispersion
5	Monochlorotrifluoroethylene/extruded (Kel-F)
6	Silicone rubber/extruded
7A	FEP/polyimide film (Kapton)
7B	Polyimide lacquer (Pyre ML)
8	Polyamide/extruded (Nylon)
9A	Polyvinylidene fluoride/extruded (Kynar)
9B	Polyvinylidene fluoride/extruded/cross-linked
10	Braid/synthetic yarn/lacquer impregnated
11	Braid/nylon/impregnated
12	Braid/polyester/impregnated
13A	Braid/glass fiber/impregnated
13B	Braid/TFE coated glass fiber/TFE finish
14	Braid/asbestos/TFE impregnated
15	Braid, weave or wrap/inorganic fiber
16	Alkane-imide polymer/extruded/cross-linked
17	Modified aromatic polyimide
18	Ethylene-tetrafluoroethylene/extruded (Tefzel)
19	Polyarylene/extruded
20	Cross-linked, extruded, modified ethylene-tetrafluoroethylene

1/ When specified on purchase order

3/ Wire intended for use in electronic equipment hook-up applications. It may also be used as an interconnecting wire when an additional jacket or other mechanical protection is provided

5/ Various combinations of primary, primary cover, and jacket insulations and unshielded, shielded, etc, constructions are available to meet application requirements. See detail wire specification.

Table 71-II. Cable, Multiconductor, Interconnection

Spec No.	Title	Basic Wire Specs.	Conductor			Shield Braid 1/			Jacket 1/		Remarks
			No. of Cond.	Volts RMS	Temp. 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexibility at -40°C or -55°C	None			Vinyl-Polymer or Synthetic (Styrene Butadiene) Rubber or Natural Rubber		Lead wire for firing explosive charge.
MIL-C-3432	Cable and Wire, Electrical (Power and Control; Semi-flexible, Flexible, & Extra-flexible, 300 and 600 Volts)	QQ-W-343 & Insulation	Unlimited and mixed sizes 3/ 5/	300 & 600	-40°C +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene Butadiene or Chloroprene Rubber	Extruded & vulcanized	
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for	M-5086/1, /2 and /3	2-7 1-7 1-7	600	105°C	 Copper Copper	No Shield Tin Tin		No Jacket No Jacket Polyamide (Nylon)	 Extruded or ImpregBraid	
		M22759/10, /12 and /13	2-7 1-7 1-7		260°C 200°C 260°C	 Copper Copper	No Shield Nickel Nickel	 85 85	No Jacket (a) (b)	 Extruded Extruded or tape	(a) Fluorinated Ethylene-Propylene (b) Polytetrafluoroethylene
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene Fluoride	Extruded	
		M81381/8, /10 and /14 M81381/11, /12 and /13	2-7 1-7 2-7 1-7 1-7		200°C 200°C 200°C 150°C 200°C	 Copper Copper Copper	No Shield Nickel No Shield Tin Nickel	 85 85 85	No Jacket FEP/Polyimide No Jacket FEP/Polyimide	 Film Tape Film Tape	
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for	MIL-C-17 QQ-W-343 & QQ-W-423 Insulation	2-78 6/	600	-53°C to +71°C	Copper	Tin	80	Sheath - Polychloroprene Primary insulation Polyethylene	Extruded & vulcanized Extruded	See Note 1/
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use	ASTM B33-74	Multiple Twisted pairs 6 pairs 100 pairs	600	75°C	Corrugated Aluminum		100	Polyethylene	Extruded	For use as telephone & telegraph signal cables in shore communication.
MIL-C-21609	Cable, Electrical, Shielded, 600 Volt (for Non-flexing Service	MIL-C-17 MIL-C-915 MIL-W-5086	2-61	600	105°C	Electrolytic tough pitch copper tape	Annealed tape tinned	Not specified	Black Polyamide over black PVC		

Table 71-II (Continued)

Spec No.	Title	Basic Wire Specs.	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond.	Volts RMS	Temp. 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-23437	Cable, Electrical, Shielded Pairs	MIL-W-16878/1	Shielded & Jacketed Twisted Pairs 1 pair-104 pairs	600	105°C	Copper	Tin	90	PVC	Extruded	For use within shore communications stations, not to be used on board ship.
						Note: Shield applied over each pair.					
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor	MIL-C-17	2-36	Var	Not Spec	Copper	Tin, Silver	85	Sheath of: PVC, Polyethylene, Polychloroprene, or FED-Teflon		(a) Flexible multi-conductor cable for use in protected areas: tunnels, wire ways, instrument racks, & conduits. (b) Polyethylene-jacketed cable suitable for underwater or direct burial applications only.
		MIL-W-76		Var	"						
		MIL-W-5845		Var	"						
		MIL-W-5846		Var	"						
		MIL-W-5908		600	105°C						
		W-16878/1		1000	105°C						
		W-16878/2		3000	105°C						
		W-16878/3		600	200°C						
		W-16878/4		1000	200°C						
		W-16878/5		600	75°C						
		W-16878/10				Note: MIL-C-27072 Applicable detail specification sheets control materials for each specific cable configuration.					
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace	MIL-W-8777	1-7	600	200°C	Var	Var	85	Var	Braided	For general aerospace flight vehicle applications.
		MIL-W-22759	1-7	Var	Var	Var	Var	85	Var	Extruded or Braided	
		MIL-W-25038	1-7	600	260°C	Var	Var	85	TFE coated glass fiber	Braided	
		MIL-W-81044	1-7	600	150°C	Var	Var	85	Var	Extruded	
		MIL-W-81381	1-7	600	Var	Var	Var	85	Var	Tape	
MIL-C-55021	Cable, Twisted Pairs and Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000	-40°C to +80°C or -65°C to 200°C	None of Copper	Tin, Silver or Nickel	90	None, PVC, Nylon TFE-Teflon	Extruded Extruded or tape	

Table 71-II (Continued)

NOTES: 1/ Polyester - Polyethylene terephthalate
TFE-Teflon - Polytetrafluoroethylene
PVC - Polyvinyl chloride
ECL-F - Polymonochlorotrifluoroethylene
FEP-Teflon - Fluorinated ethylene propylene
PVF - Polyvinylidene fluoride

2/ See applicable detail specification sheet for temperature limitation

3/ See applicable detail specification sheet for materials control of specific cable configurations

4/ Although the specification does not limit the number of conductors in a cable, the size, weight, and flexibility are determining factors.

5/ Available in three classifications:

Class L - Light Duty - to withstand severe flexing and frequent manipulation

Class M - Medium Duty - to withstand severe flexing and mechanical abuse

Class H - Heavy Duty - to withstand severe flexing and mechanical abuse and ability to withstand severe service impacts such as to be run over by tanks or trucks.

6/ See applicable detail specification sheet for mechanical test requirements for cold bend, cold bend torque, impact bend, and twist

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

REQUIREMENT 72

SUBSTITUTABILITY

1. Purpose. This requirement establishes criteria for the selection and application of substitute parts.

2. Document applicable to Requirement 72:

MIL-STD-480	Configuration Control - Engineering Changes, Deviations and Waivers

3. Substitution criteria. Except as noted in paragraph 4, substitute parts shall comply with the following:

3.1 Substitution of parts covered by military specifications and standards that include substitutability or supersession information is acceptable. This type substitution does not require submission of engineering change proposals, deviations, or waivers in accordance with MIL-STD-480.

3.2 When the equipment design specifies a commercial part, a military specification part may be substituted when the form, fit, function and characteristics of the military part are equal to or better than those of the specified commercial part under equivalent environmental conditions. This type substitution is subject to applicable configuration control procedures of MIL-STD-480.

4. Initial qualification/reliability demonstration. Substitute parts with quality/reliability characteristics superior to those specified in the parts list shall not be used in equipment to be subjected to qualification or demonstration tests.

REQUIREMENT 73

STANDARD ELECTRONIC MODULES

1. Purpose. This requirement establishes criteria for the selection and application of standard electronic modules (SEM).

2. Documents applicable to Requirement 73:

MIL-M-28787	Modules, Standard Electronic, General Specification for
MIL-STD-1378	Requirements for Employing Standard Electronic Modules
MIL-STD-1389	Design Requirements for Standard Electronic Modules

3. Application. Requirements for the design and employment of standard electronic modules shall be in accordance with MIL-STD-1389 and MIL-STD-1378, respectively. Standard electronic modules shall be in accordance with MIL-M-28787.

REQUIREMENT 74

GROUNDING, BONDING, AND SHIELDING

1. Purpose. This requirement establishes grounding, bonding, and shielding interface criteria for installation of electronic equipment.

2. Documents applicable to Requirement 74:

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-STD-188-124	Grounding, Bonding, and Shielding
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety Shielding
MIL-STD-1542	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities
MIL-STD-1857	Grounding, Bonding, and Shielding Design Practices

3. General. Grounding, bonding, and shielding provisions shall be incorporated into equipment design, as necessary, to enable installation of equipment into the applicable platform or facility. The grounding, bonding, and shielding installation and interface requirements are specified in the following documents:

Aerospace ground support facilities	MIL-B-5087
Aircraft and space vehicles	MIL-B-5087
Ground telecommunications C-E equipment	MIL-STD-188-124
Shipboard equipment	MIL-STD-1310
Ground space systems facilities	MIL-STD-1542
Other Army ground equipment	MIL-STD-1857

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